http://jpkc.fudan.edu.cn/s/426/main.htm

The Respiratory System

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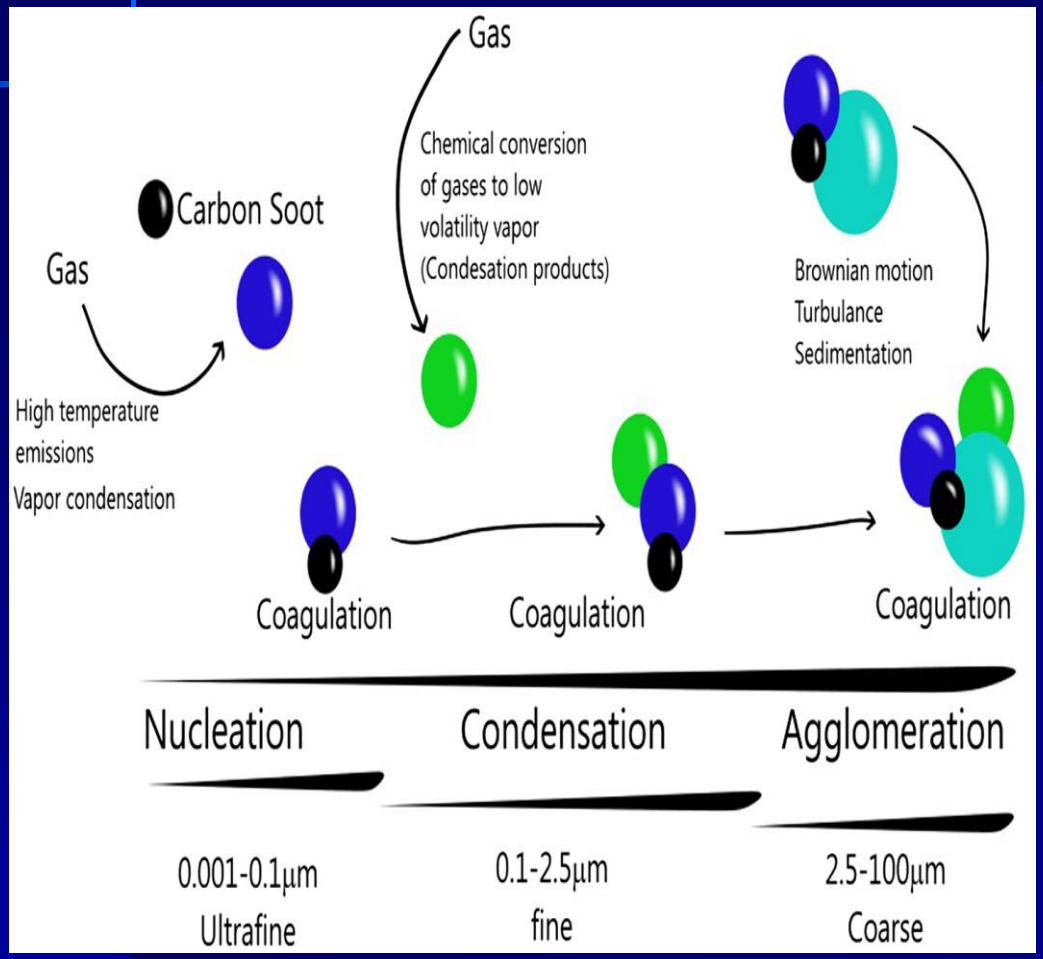
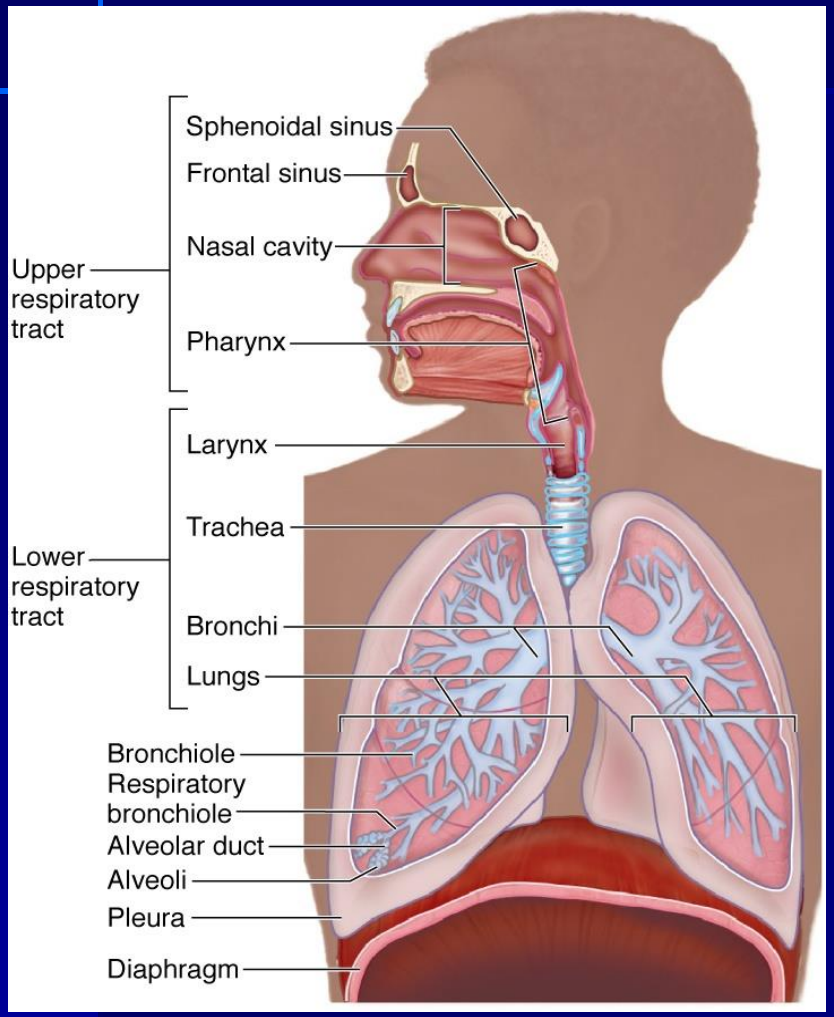
Particulate Matter and Its Atmospheric Dynamics



- Particles **nucleation** is generated by gases emission.
- **Condensation** can occur by cooling, producing particles.
- The **interaction between primary** particles **and secondary** particles constitute the **coagulation**.
- In this way, the particles can **increase their size and composition**.

Particulate Matter and Its Fate in the Respiratory System



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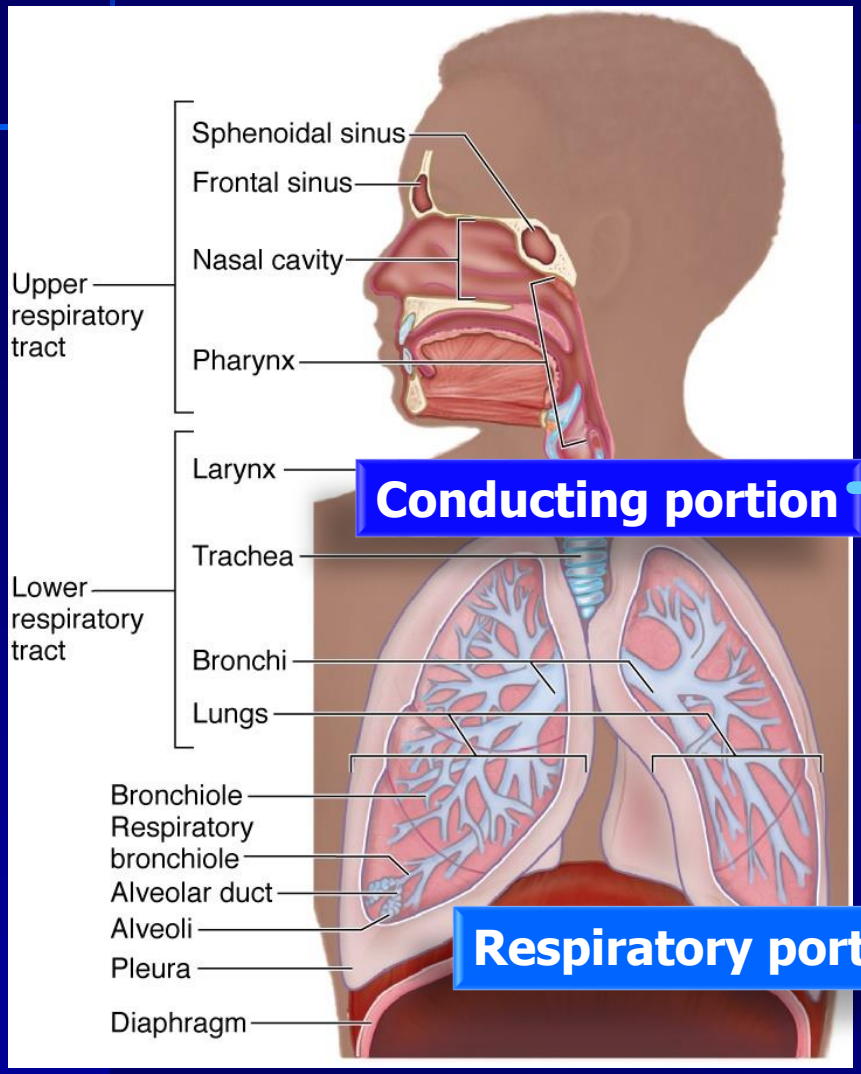
OBJECTIVES

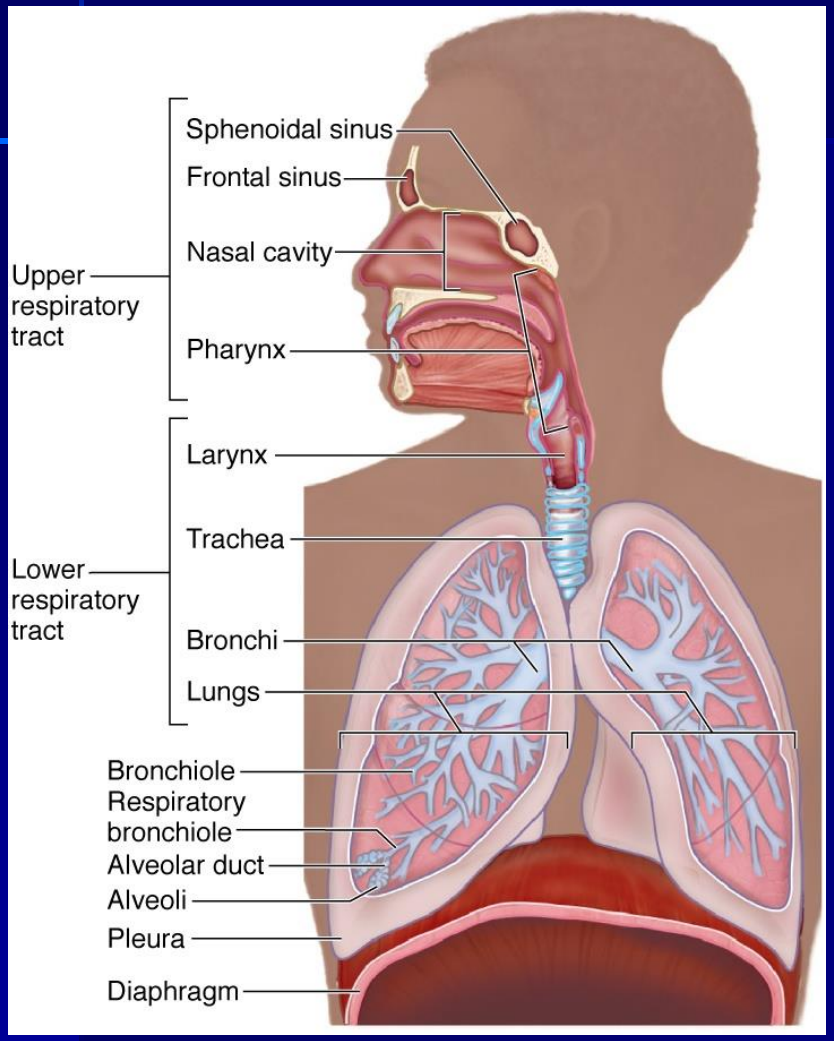
- Structure and function of nasal mucosa including the olfactory mucosa
- Structure and function of trachea and bronchial tree, conducting portion, and respiratory portion in lungs
- Structure and function of type I and type II pneumocytes
- Function of pulmonary surfactant
- Structure and function of alveolar septum and blood-air barrier

General Introduction (1)



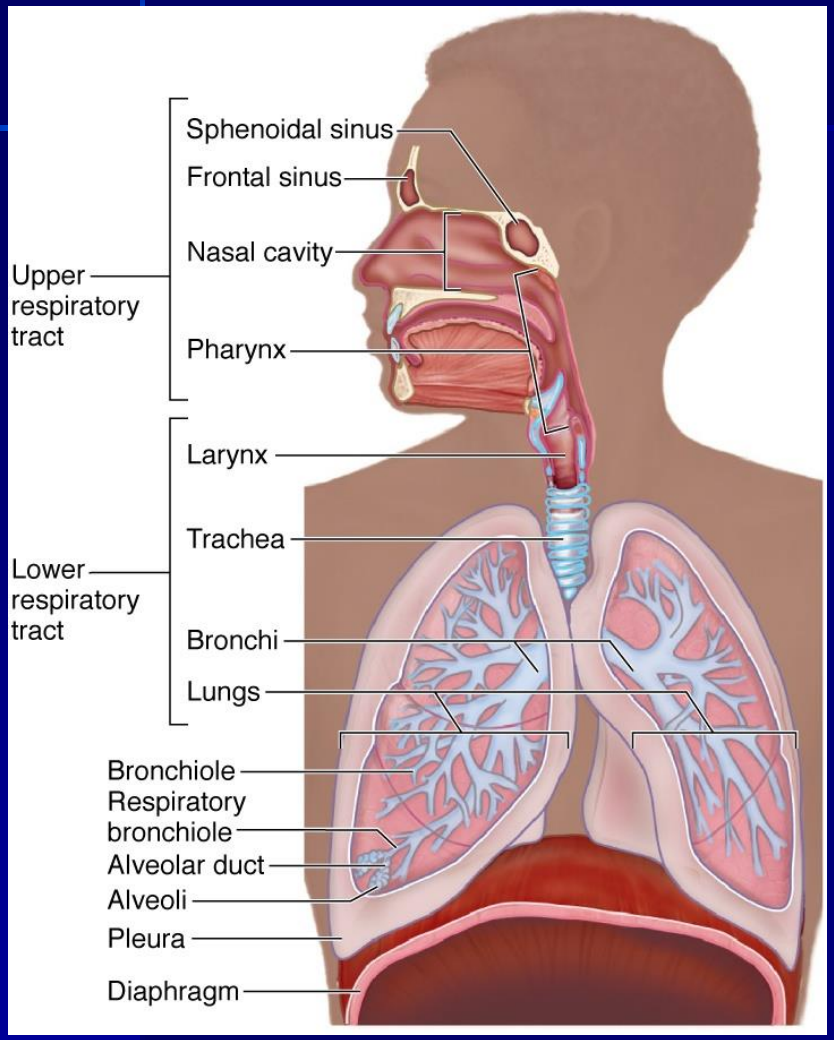
- **Constitution**:
  - Upper respiratory tract:
    - Nasal cavity and sinus
    - Pharynx
  - Lower respiratory tract:
    - Larynx
    - Trachea
    - Bronchi
    - Lungs
      - bronchioles
      - terminal bronchioles
      - respiratory bronchioles
      - alveolar ducts
      - alveolar sac
      - alveoli

General Introduction (2)



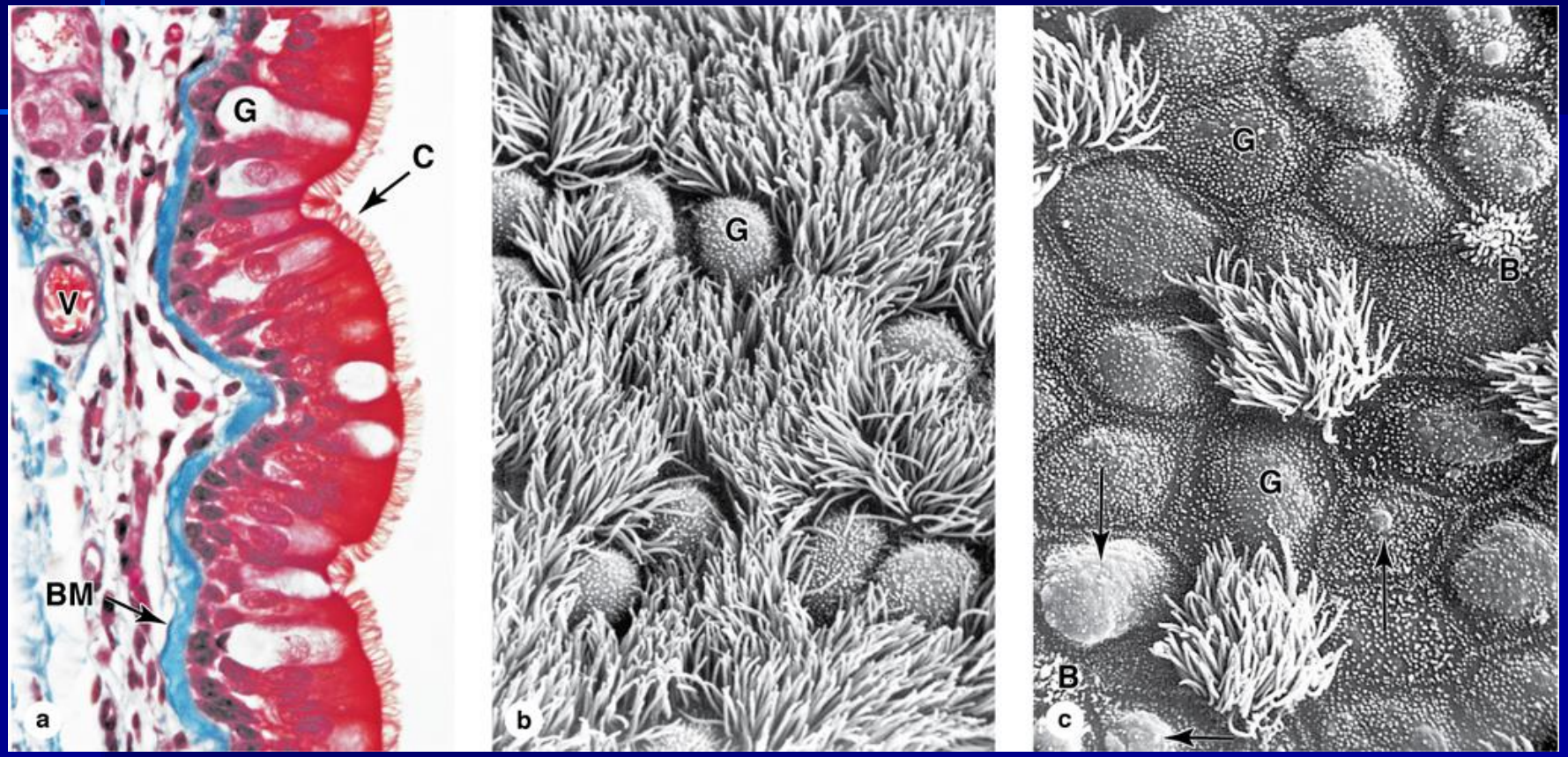
- **Respiratory mucosa:**
  - Epithelium
  - Lamina propria
    - Connective tissue
      - Elastic fibers
    - Mucous or serous glands
    - Blood vessels
    - Lymphoid tissue
      - Plasma cell
      - MALT
- **Submucosa**
  - Hyaline cartilage
- **Adventitia**

General Introduction (3)



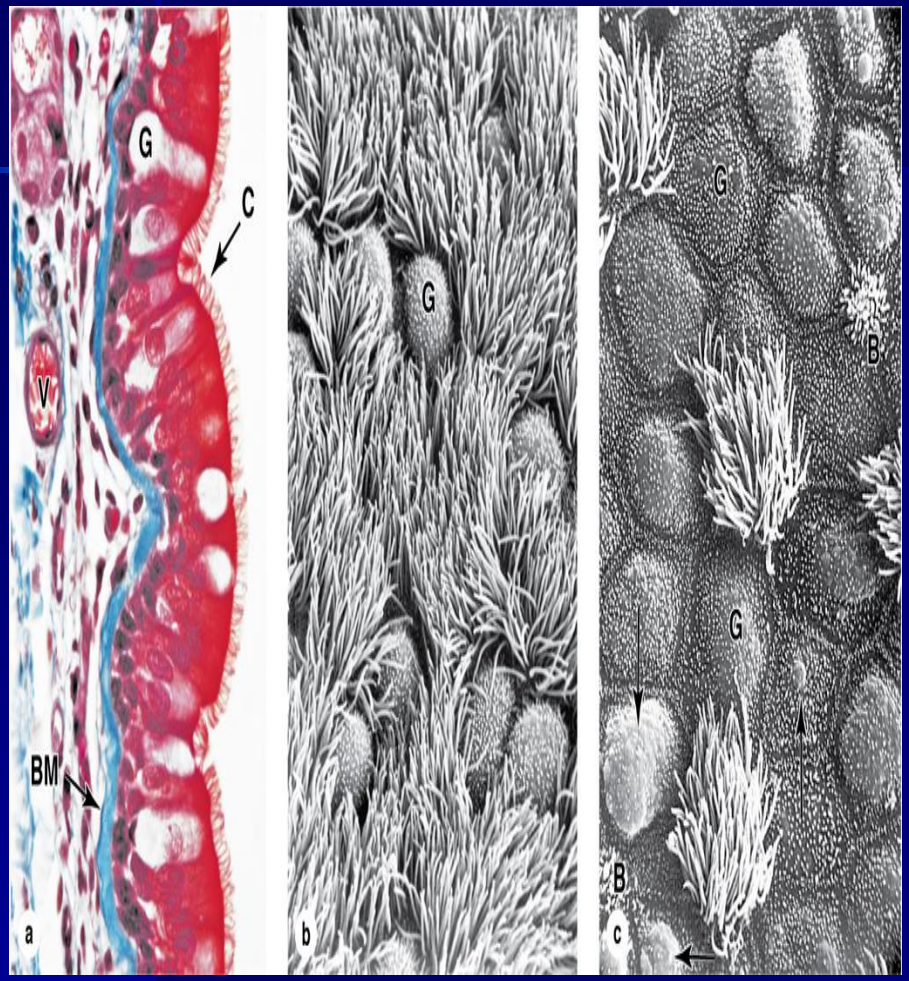
- **Functions:**
  - Gas exchange
    - Alveoli
    - Blood - air barrier
  - Synthesis and release of pulmonary surfactant at the apical surface of alveolar cells
  - Condition the inspired air
    - Ciliated cells & mucous layer
    - Rich vasculature
  - Olfaction
    - Bipolar neuron

Respiratory Epithelium



Ciliated pseudostratified columnar epithelium

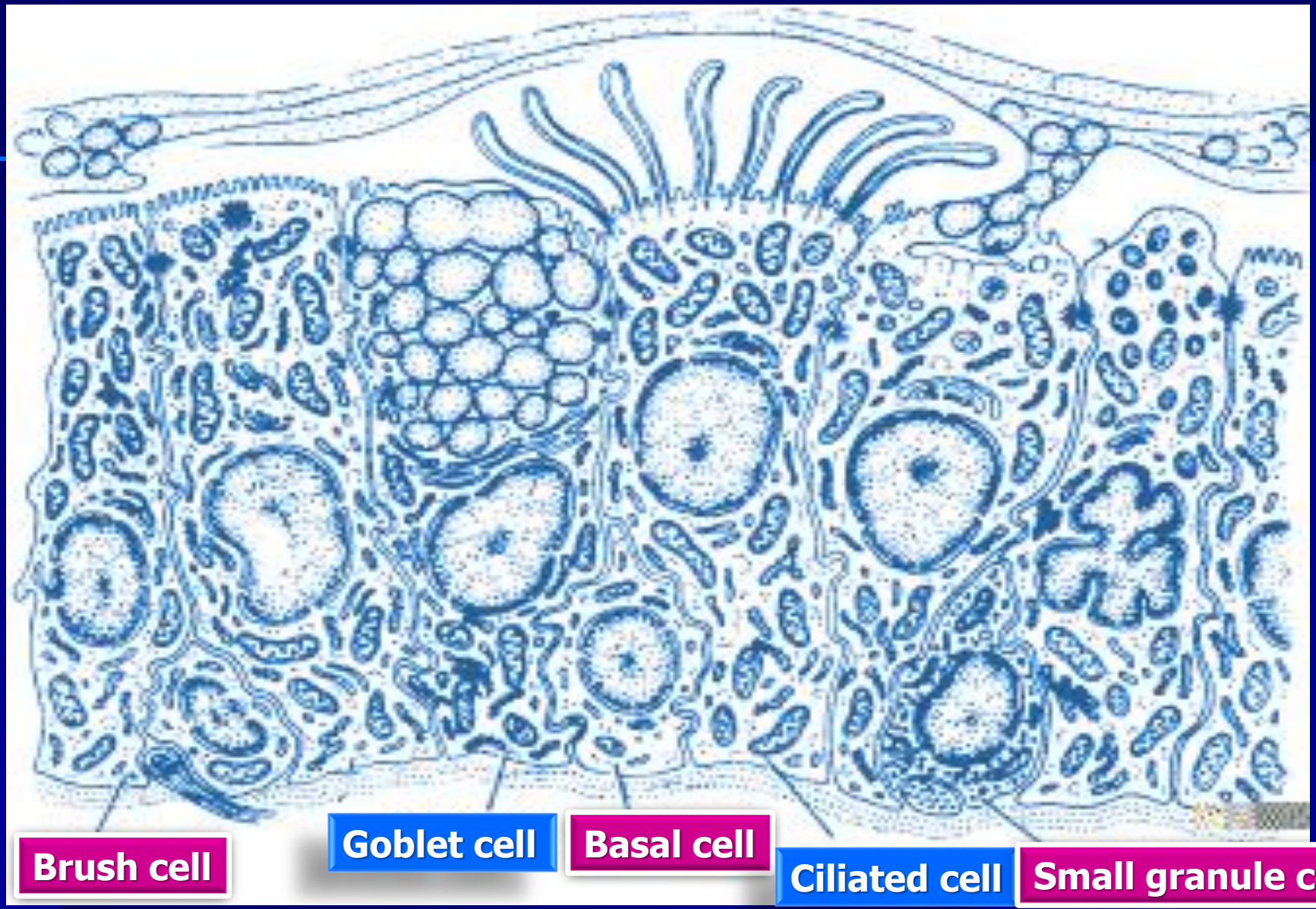
Respiratory Epithelium



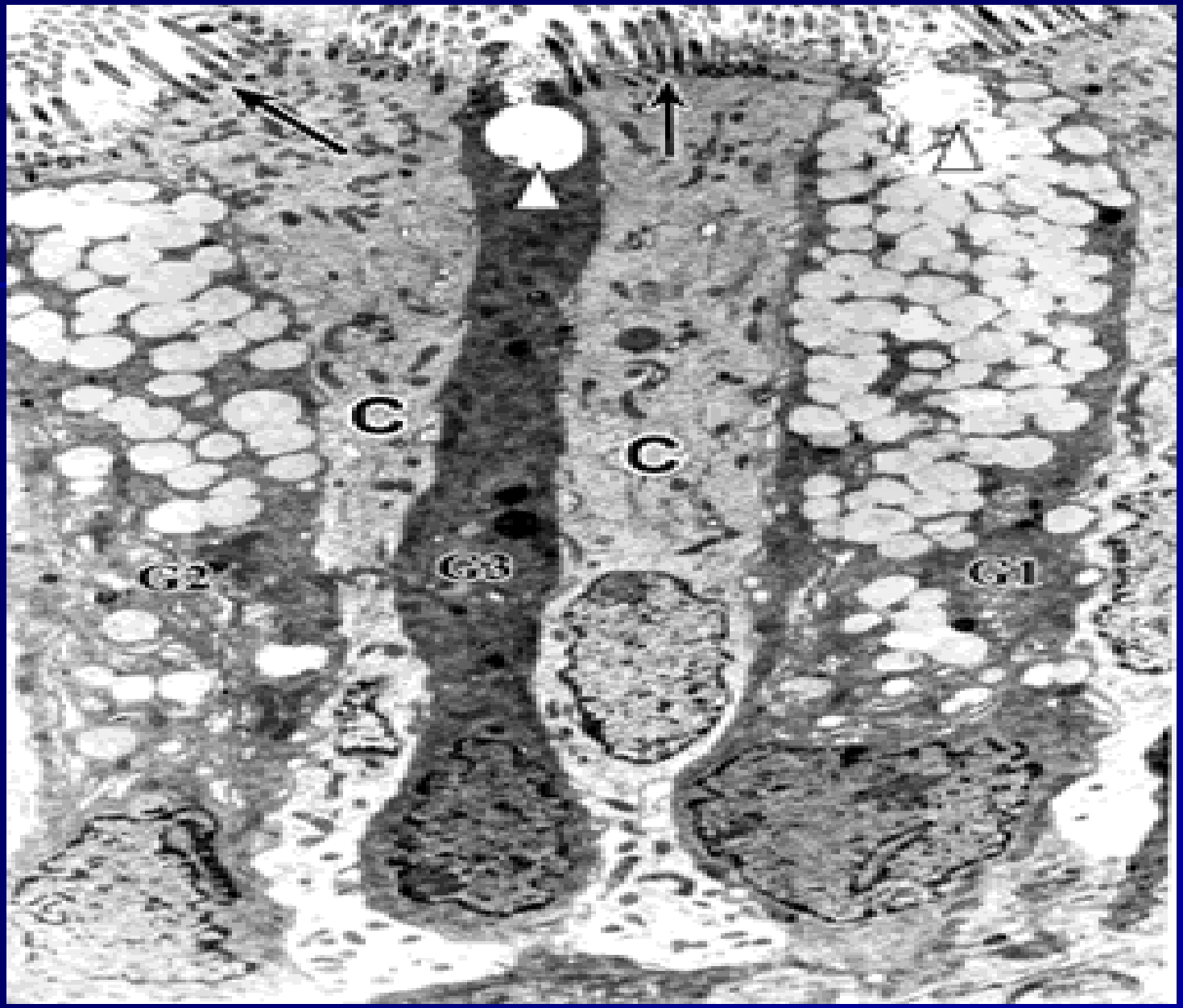
Ciliated Pseudostratified Columnar Epithelium

- **Ciliated columnar cells (C):**
  - abundant
- **Goblet cells (G)**
  - Filled in the apical portion with granules of mucin glycoprotein
- **Brush cells (B):**
  - Sparsely scattered
  - Express signal transduction components
  - Have afferent nerve endings on the basal surface
  - As chemosensory receptors
- **Small granule cells:**
  - Part of the diffuse neuroendocrine system
- **Basal cells**
  - Stem cells

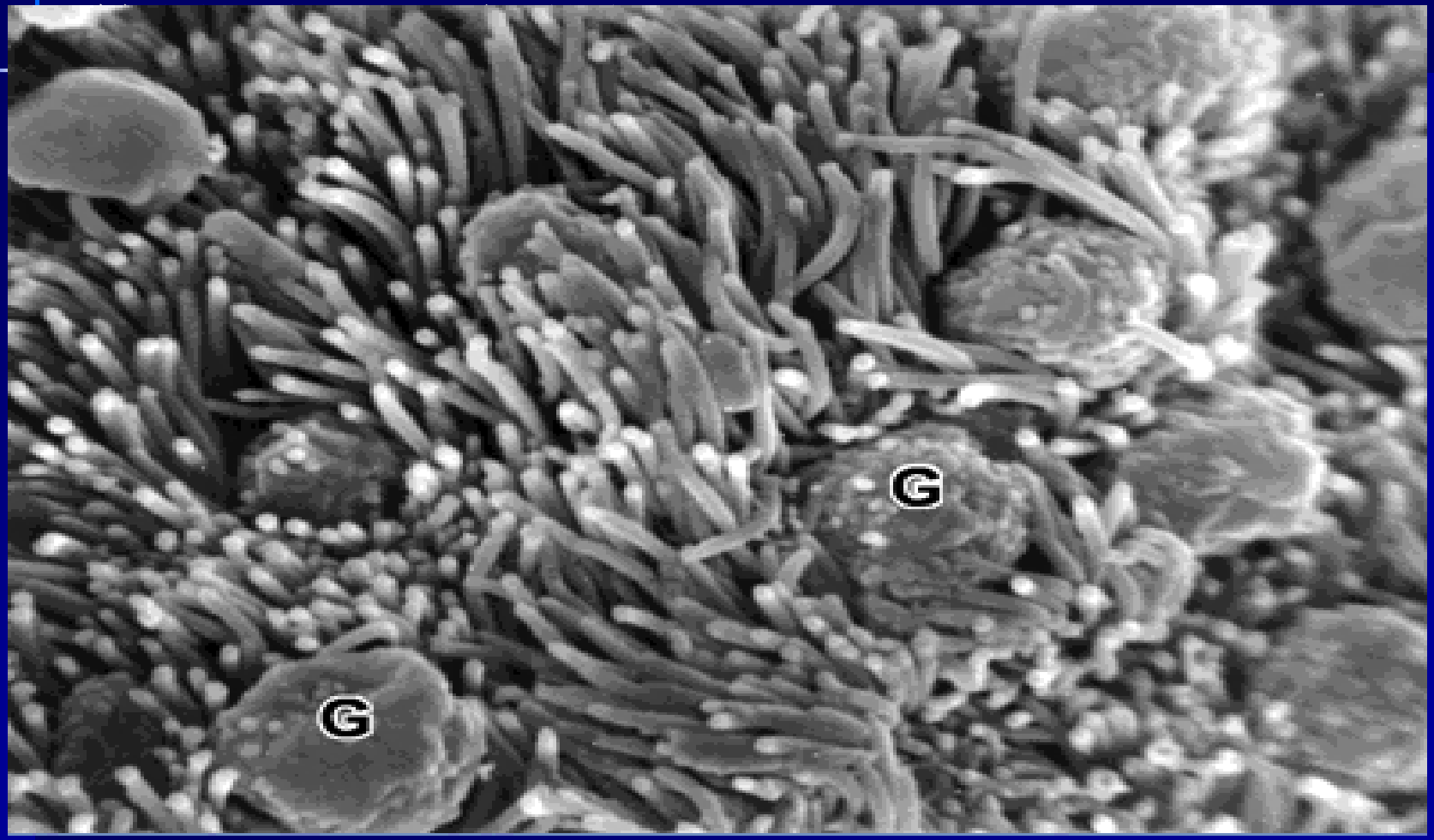
Respiratory Epithelium (trachea)



Respiratory Epithelium (rat trachea)



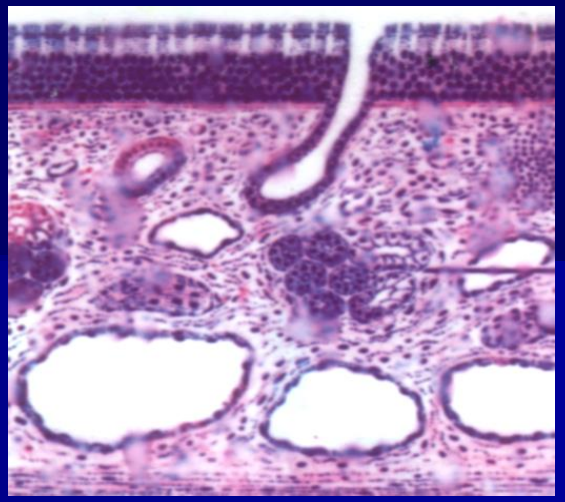
Respiratory Epithelium (dog trachea)

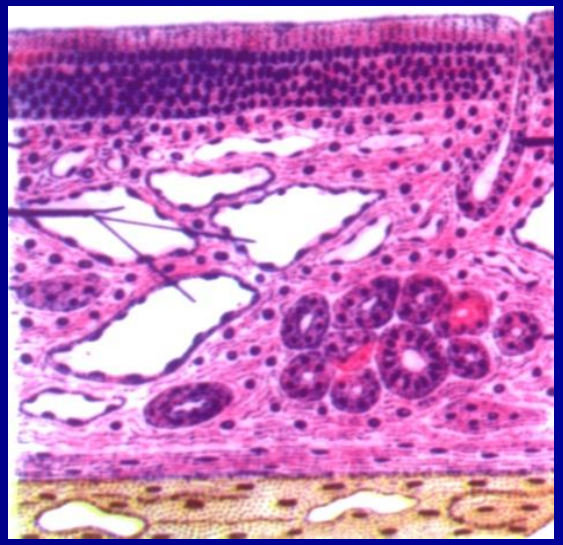


Nasal Cavities

- External nasal vestibule
  - Lined with keratinized stratified squamous epithelium
- Internal nasal cavities
  - Middle and inferior conchae
    - Lined with respiratory epithelium
    - Lamina propria
      - Large venous plexuses
      - Rich vascular system
  - Superior conchae:
    - Lined with olfactory epithelium

respiratory epithelium



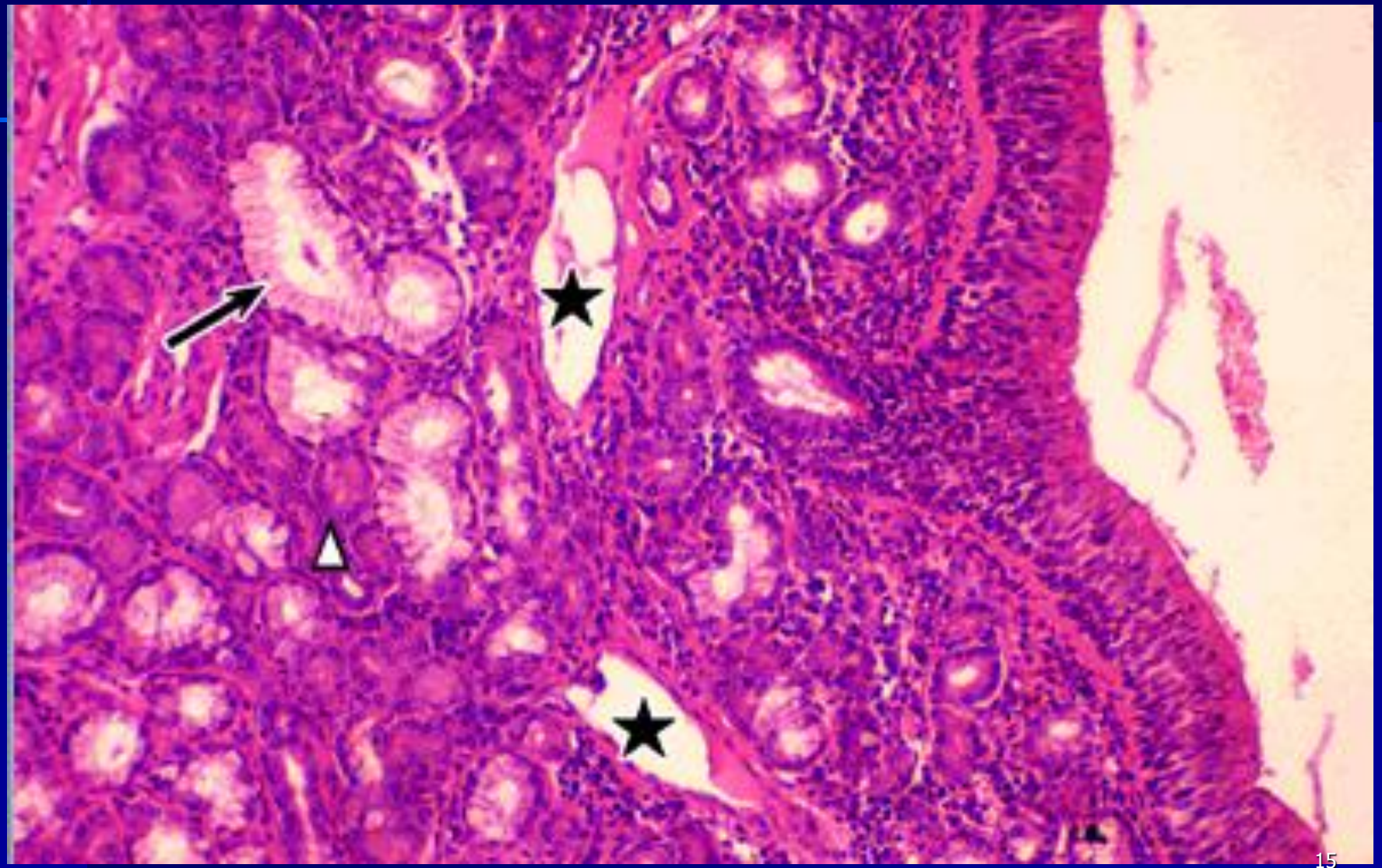


olfactory epithelium

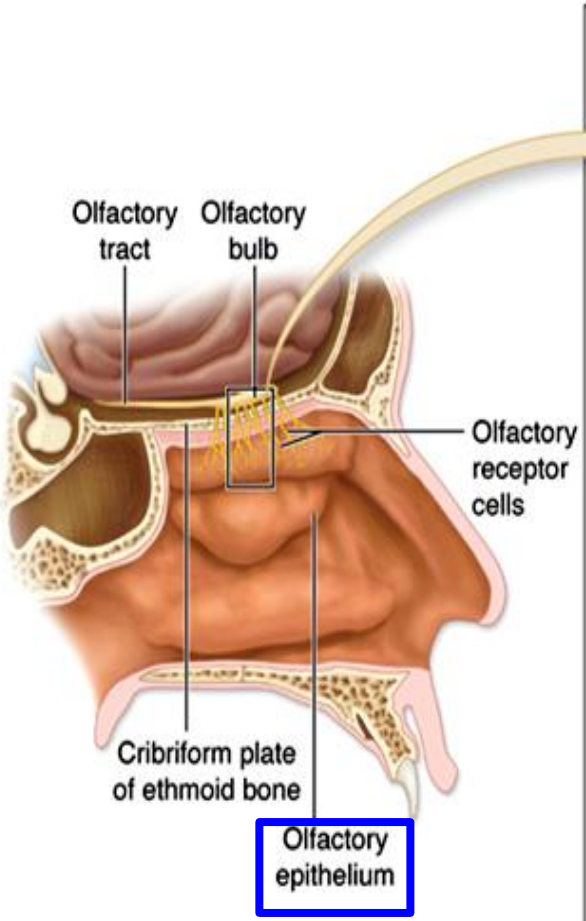
Functions of respiratory mucosa of nasal cavities

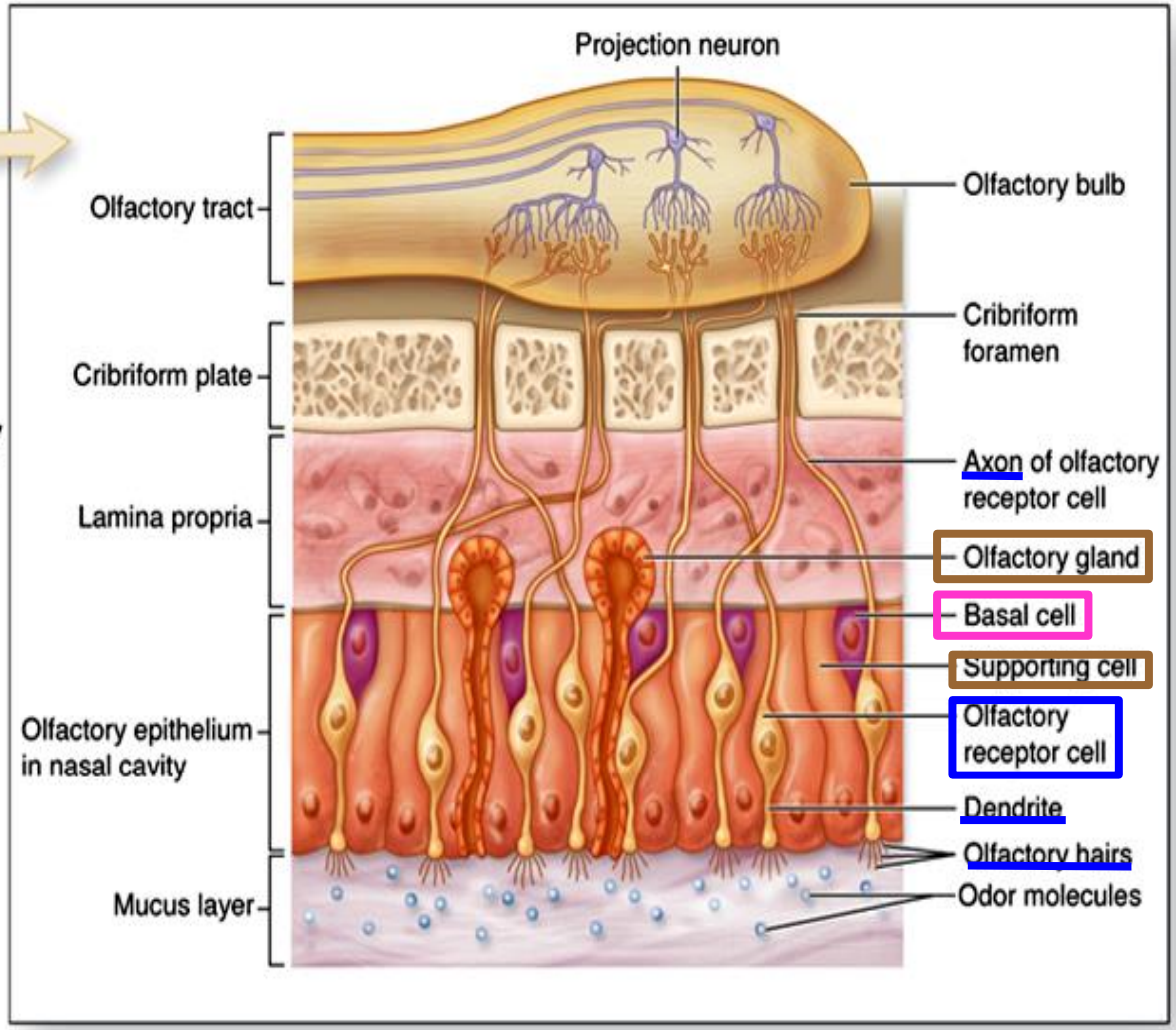
- To condition inspired air before entering the lungs by
  - Cleaning (moist vibrissae, ciliated cells of respiratory epithelium)
  - Moistening (mucus-secreting cells of respiratory epithelium, mucous and serous glands in the mucosa)
  - Warming (the rich vasculature in the lamina propria)

RESPIRATORY MUCOSA of NASAL CAVITY



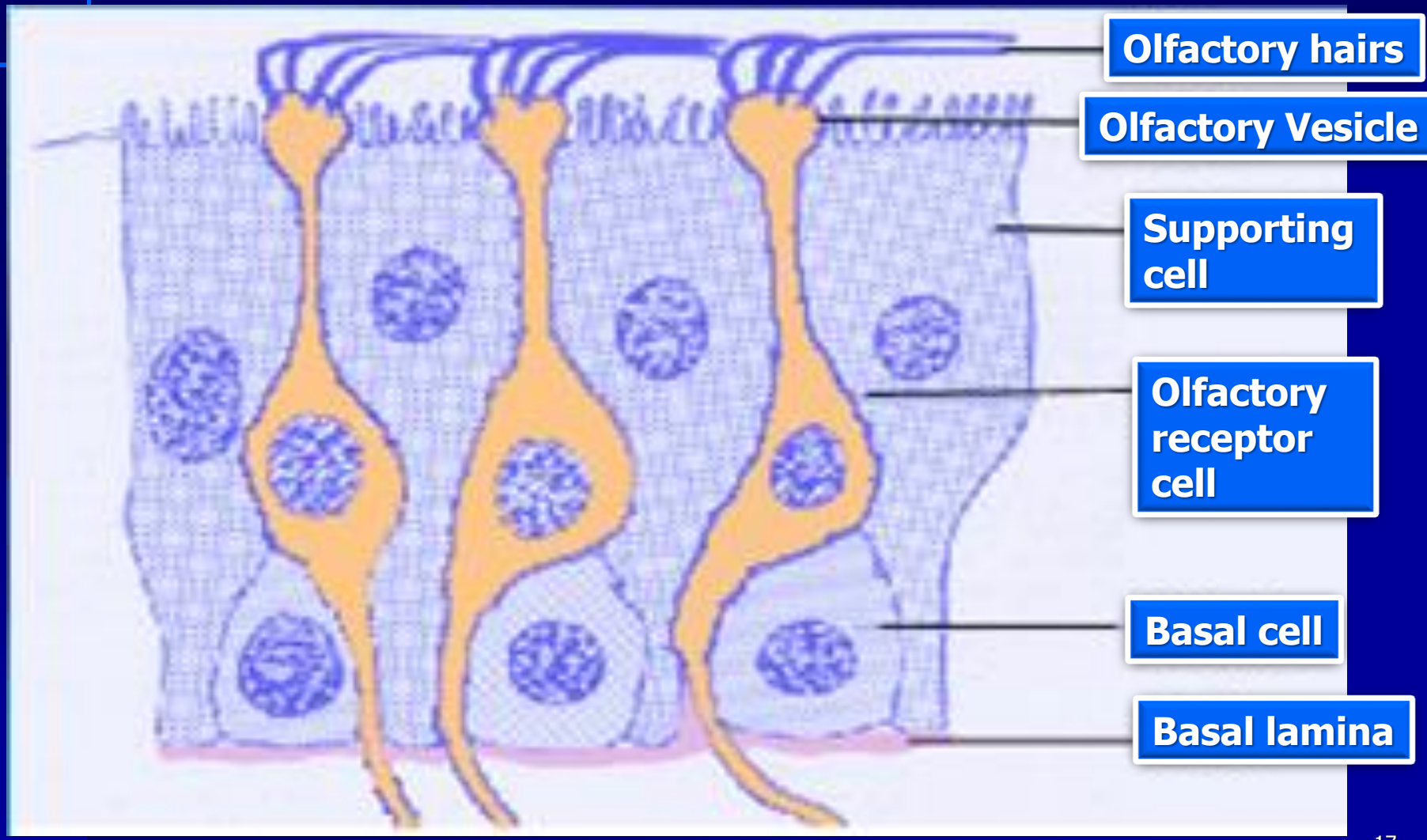
OLFACTION



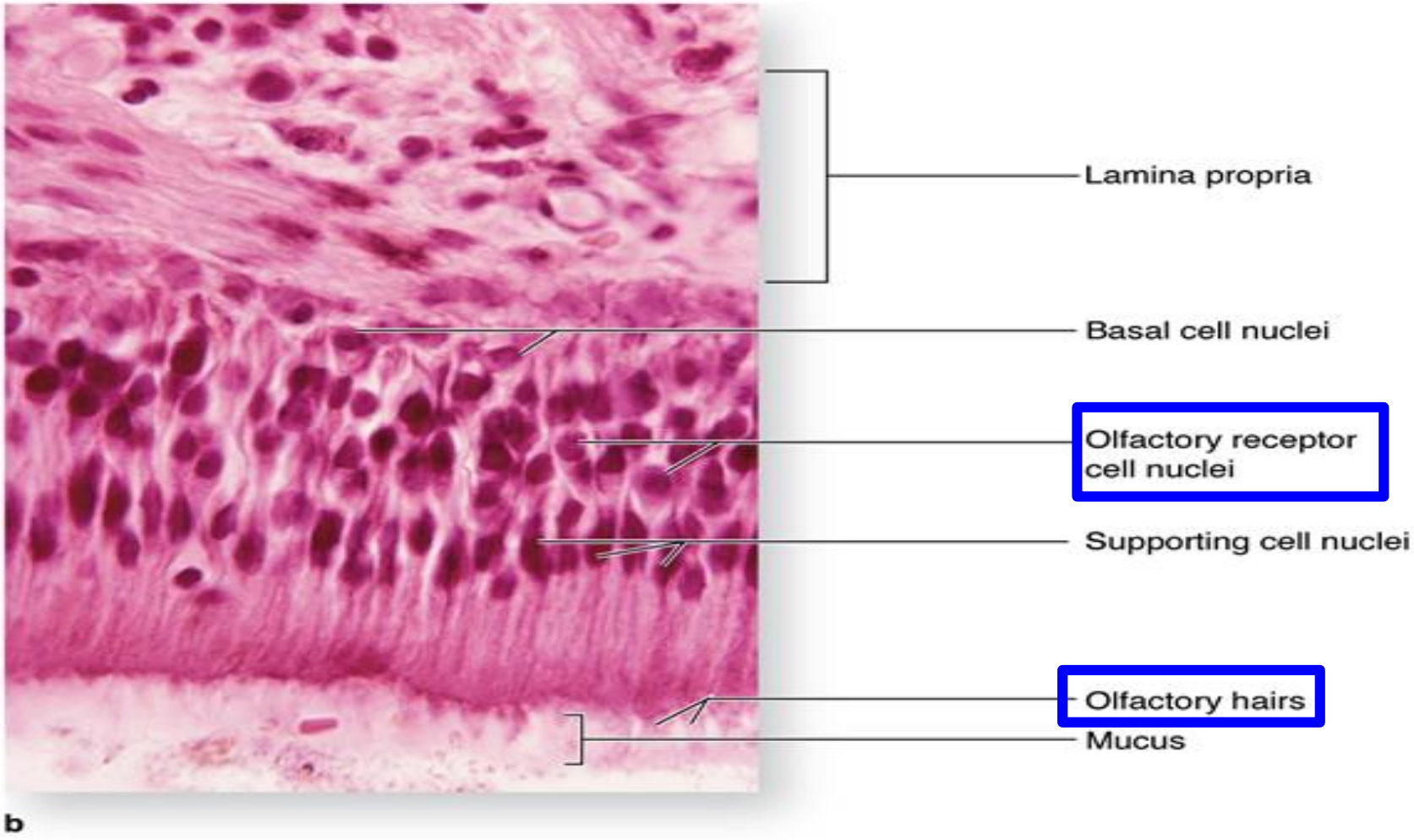


Superior Conchae

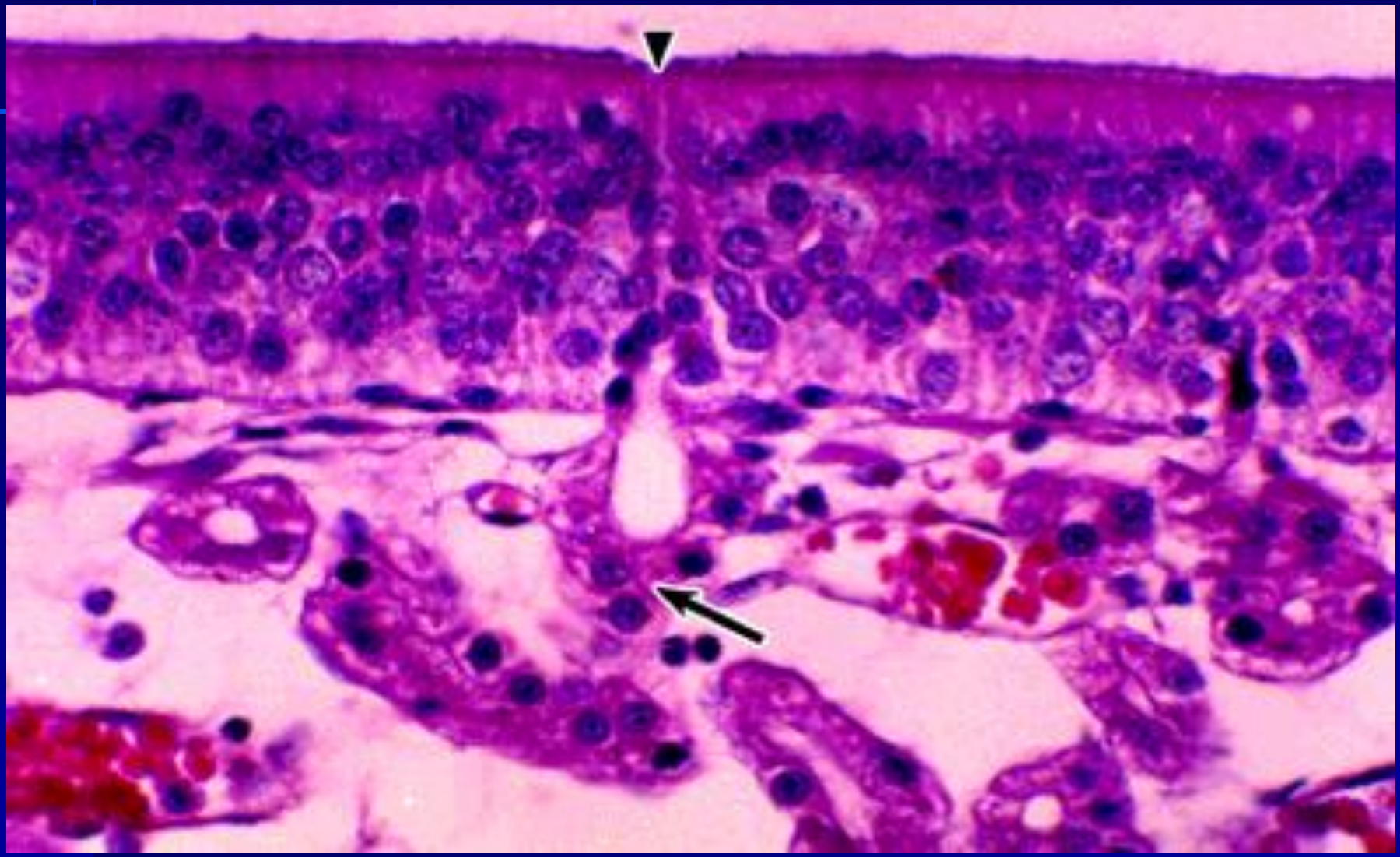
OLFACTORY EPITHELIUM

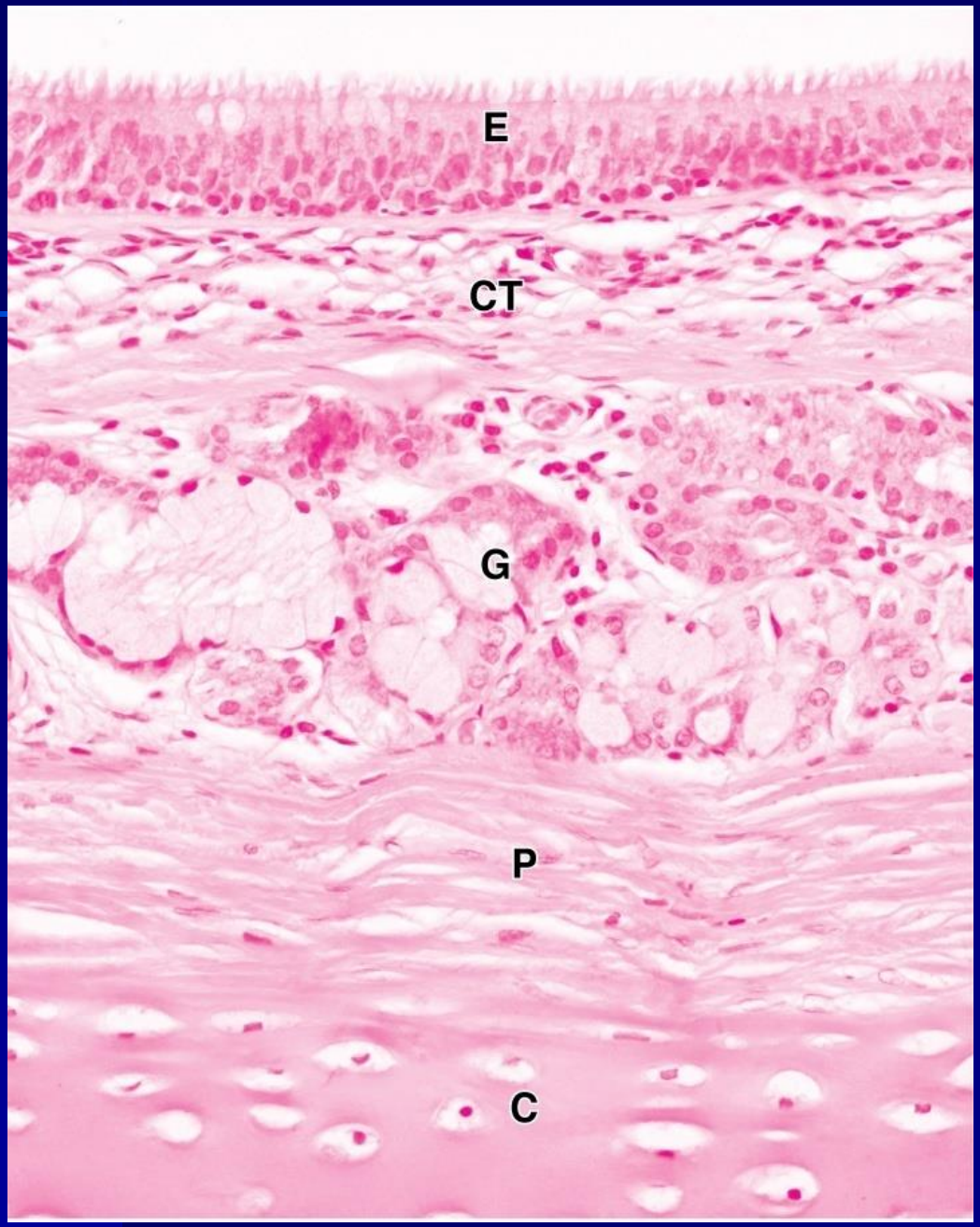


OLFACTORY MUCOSA



OLFACTORY EPITHELIUM

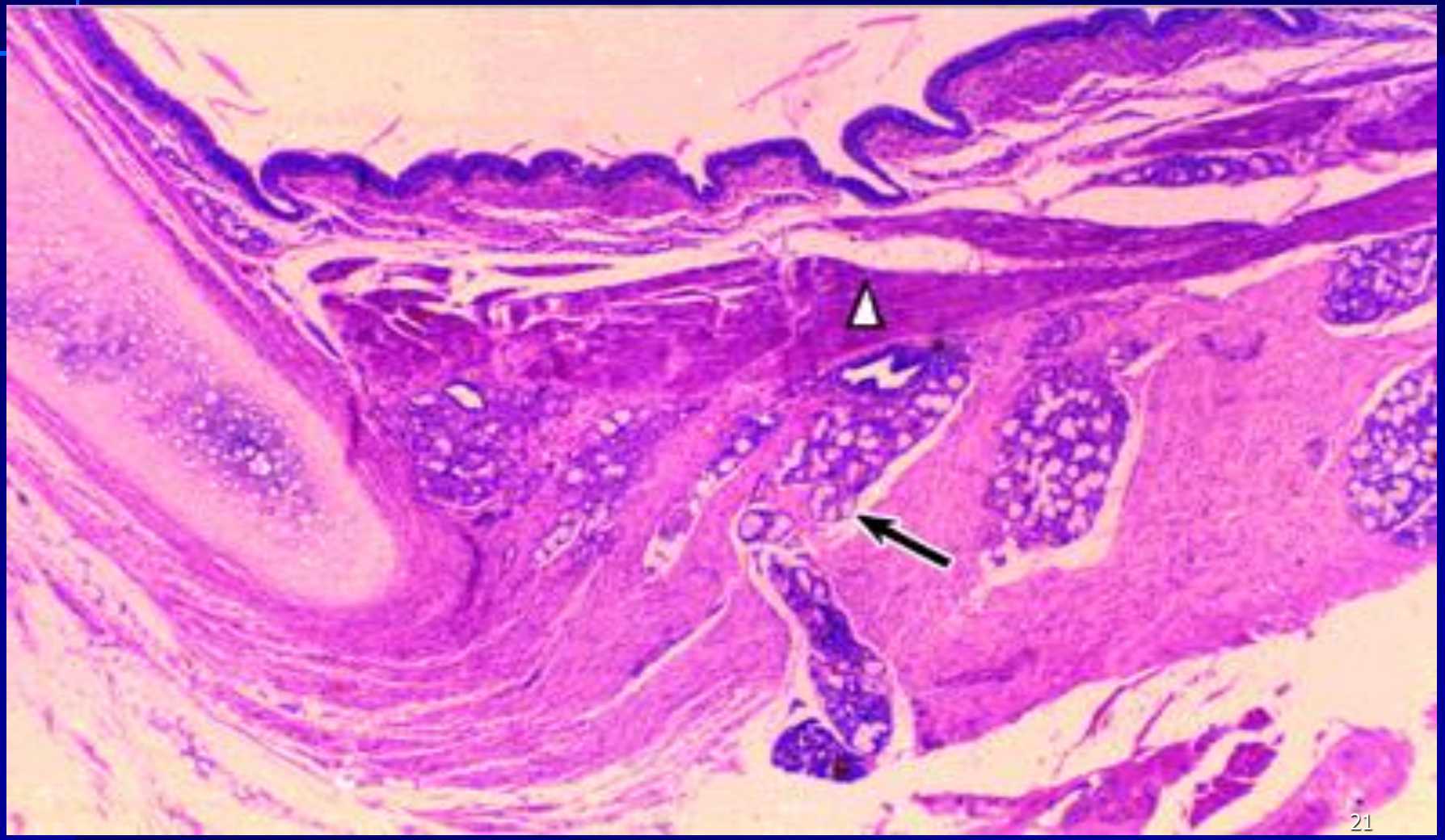




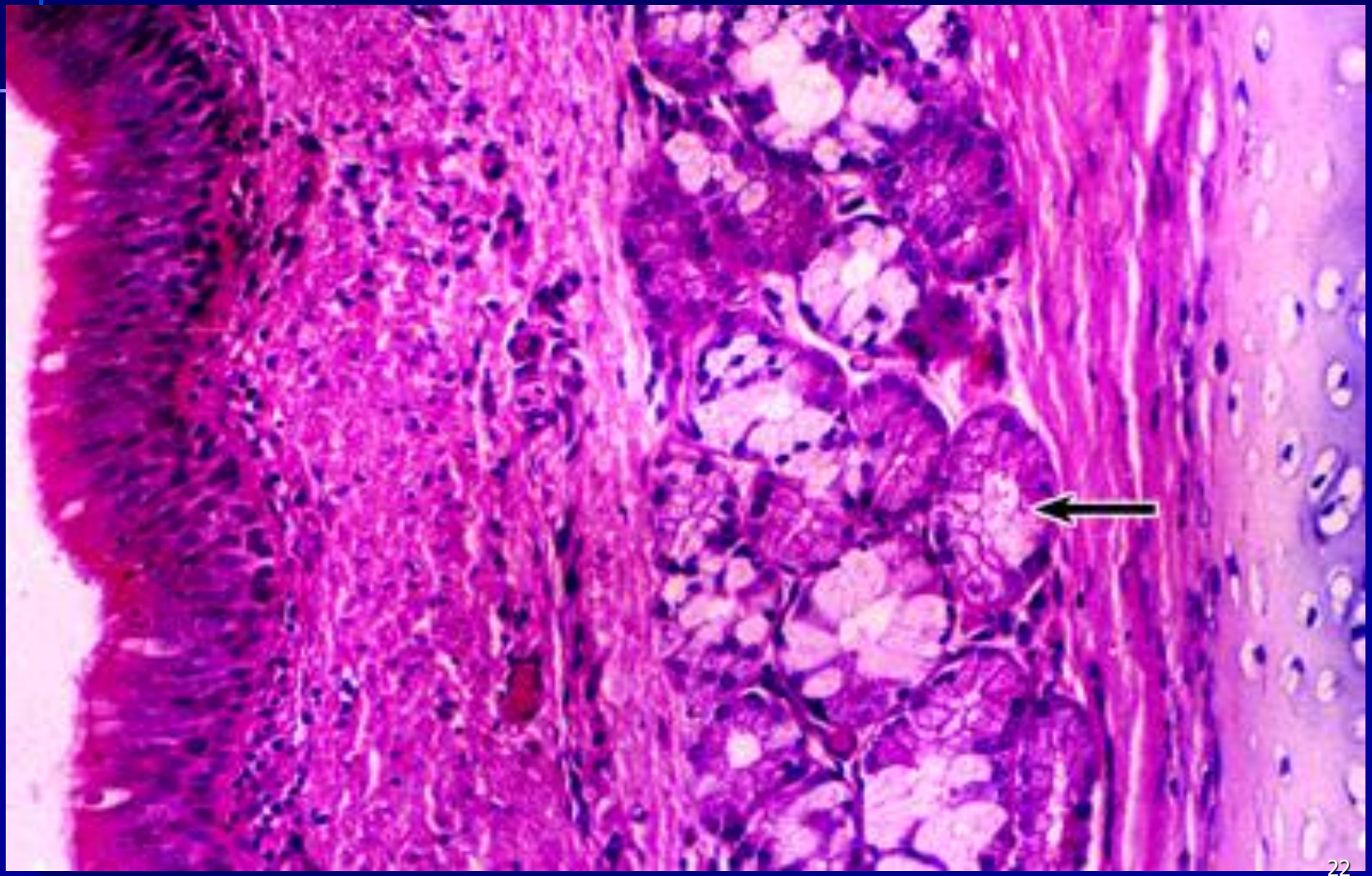
TRACHEA

- **Respiratory mucosa**
  - **Ciliated pseudostratified columnar epithelium (E)**
  - **Seromucous glands (G) in the lamina propria**
- **Submucosa:**
  - **C-shaped rings of hyaline cartilage (C)**
- **Adventitia**

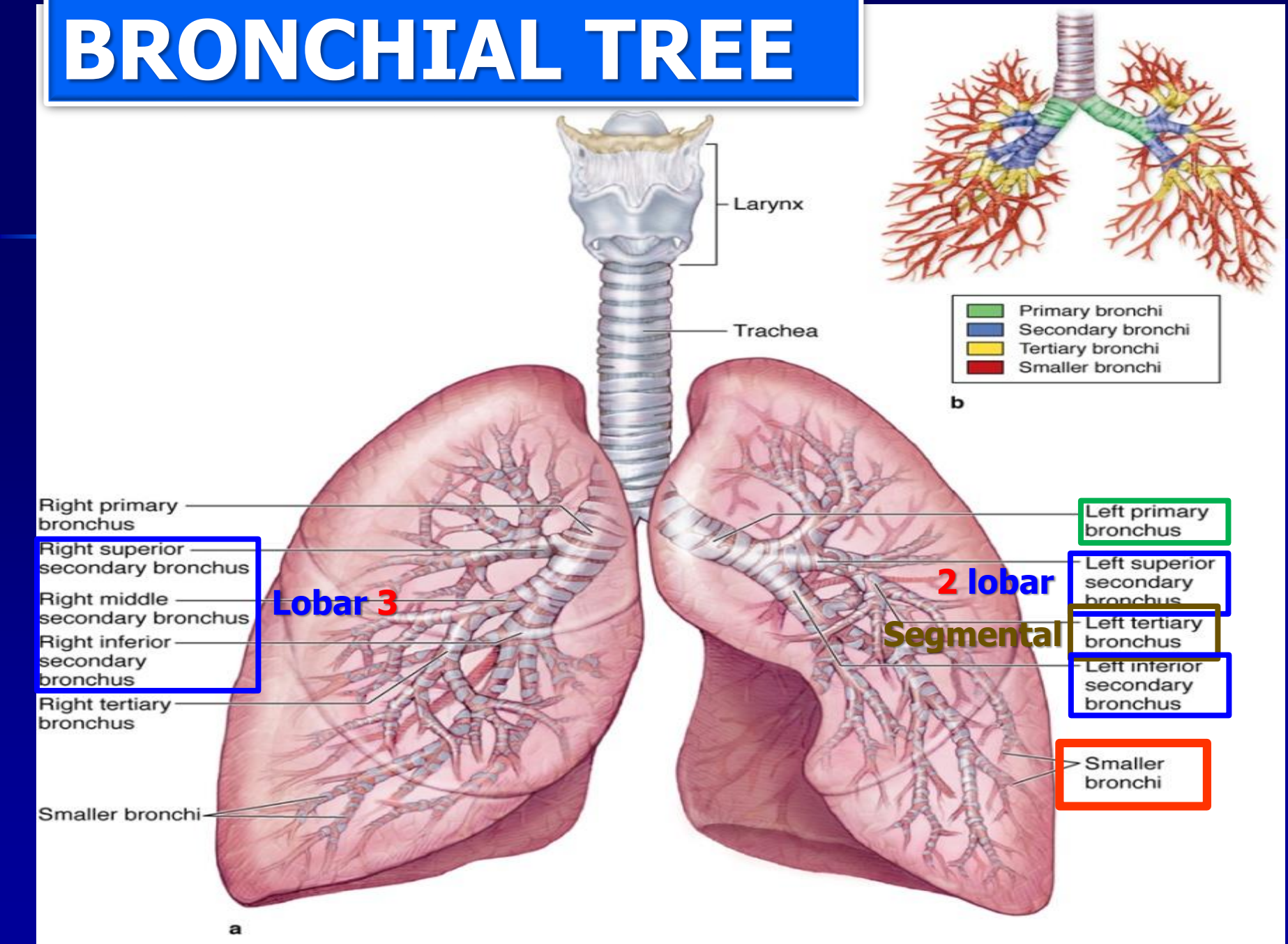
Human trachea mucosa (posterior)



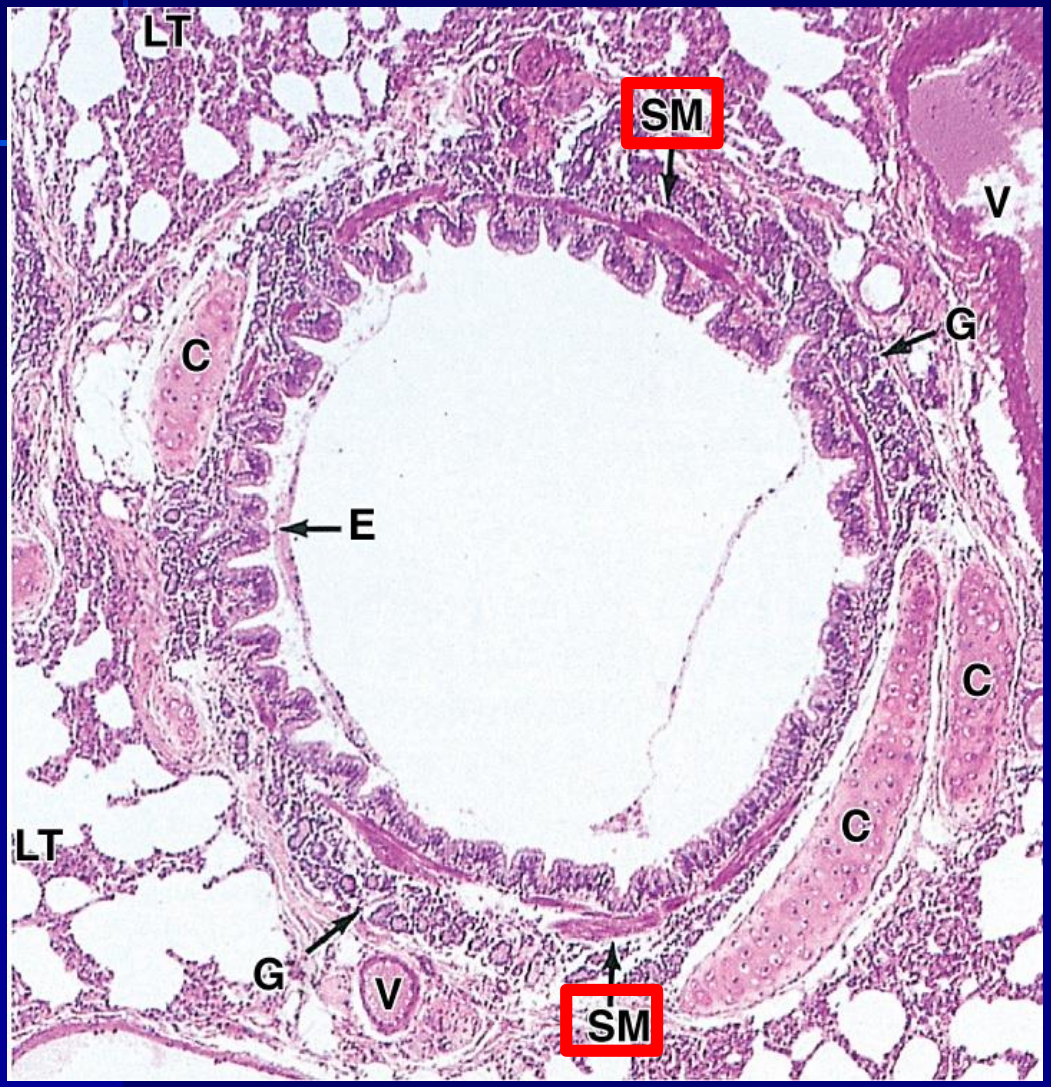
Human trachea mucosa and submucosa



BRONCHIAL TREE

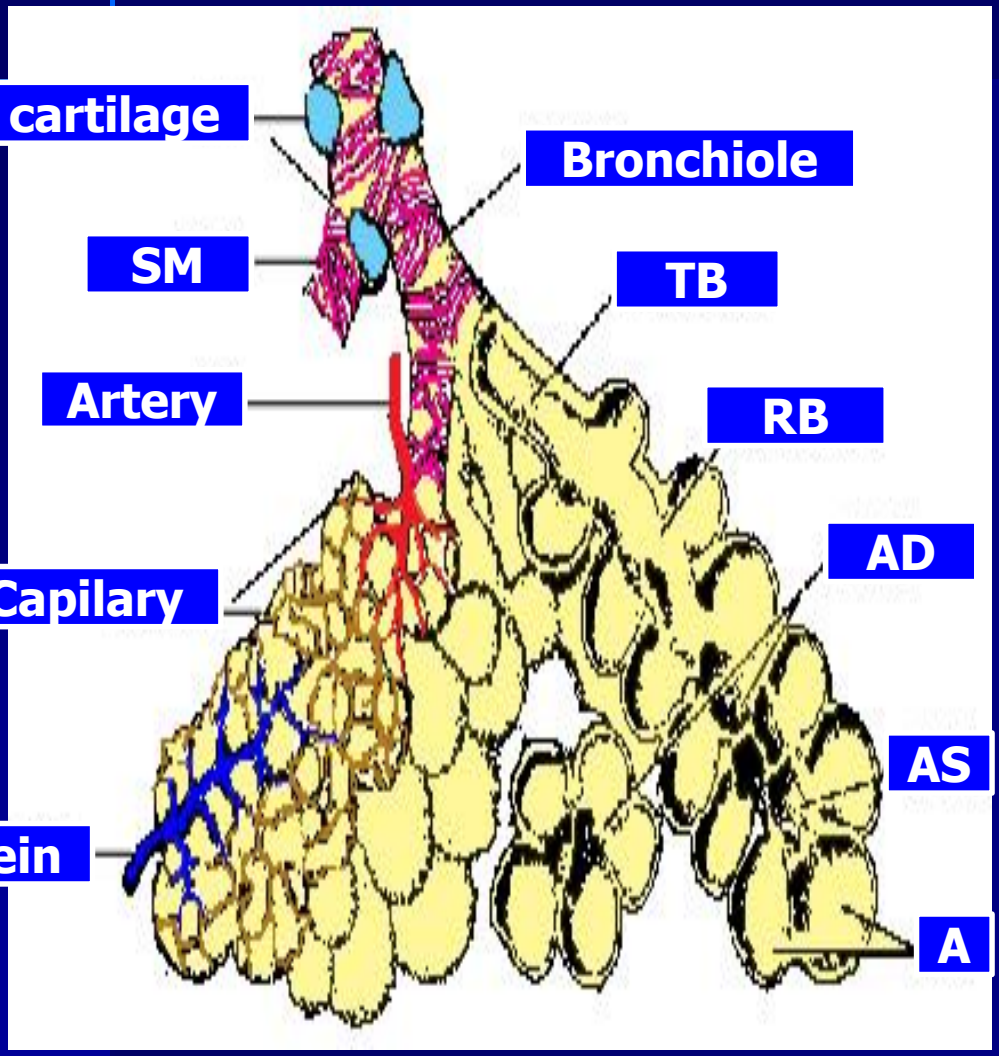


TERTIARY BRONCHUS



- **Bronchopulmonary segment**
  - **Tertiary** bronchi
  - **Smaller** bronchi
  - **Bronchioles**
    - **Pulmonary lobule**
      - **Terminal** bronchioles
      - **Respiratory portion**
- **With its own CT capsule and blood supply**

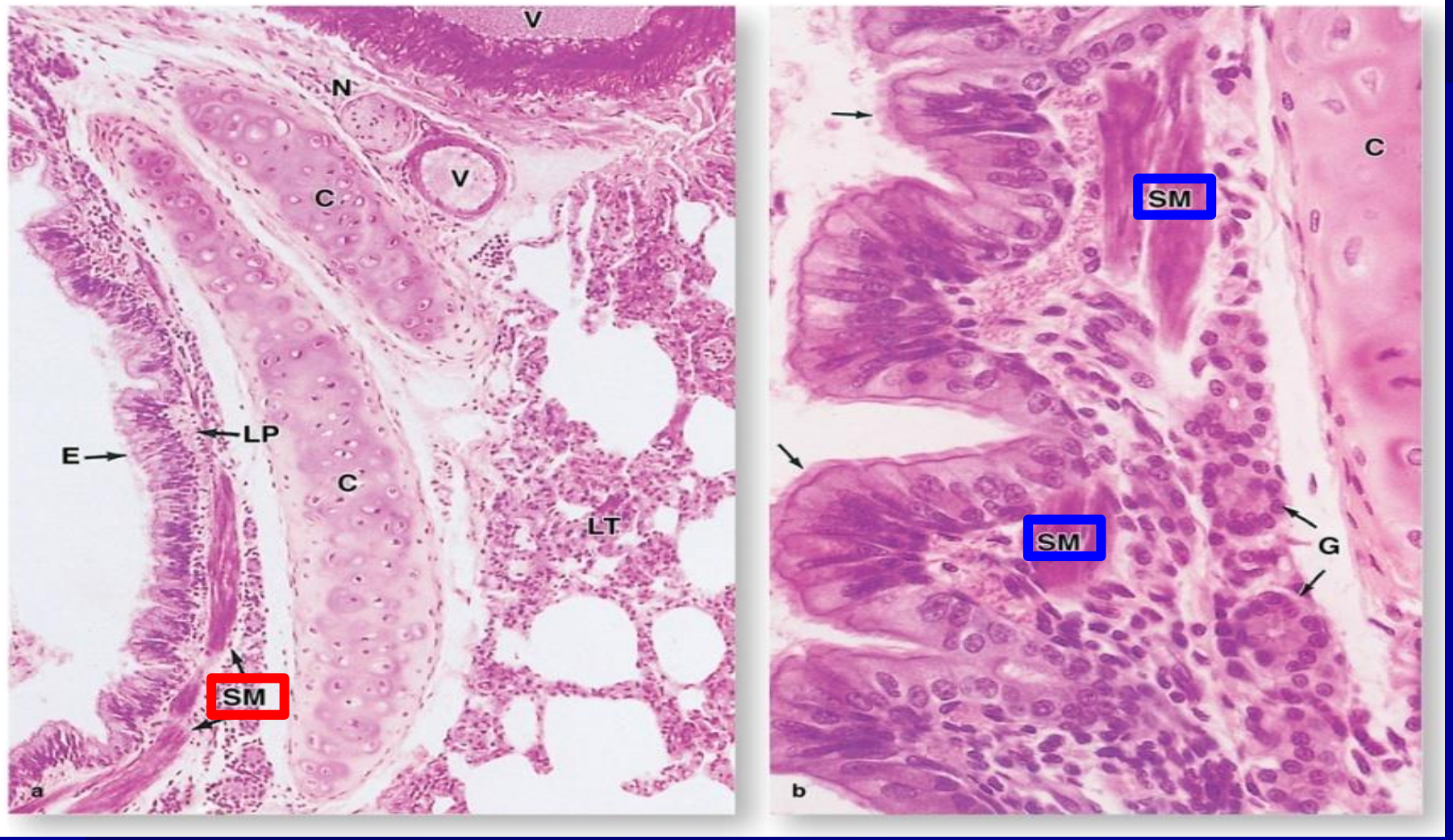
Pulmonary lobule



- Bronchioles (B)
- Terminal bronchioles (TB)
- Respiratory portion
  - respiratory bronchiole (RB)
  - alveolar duct (AD)
  - alveolar sac (AS)
  - pulmonary alveolus (A)

BRONCHIAL WALL

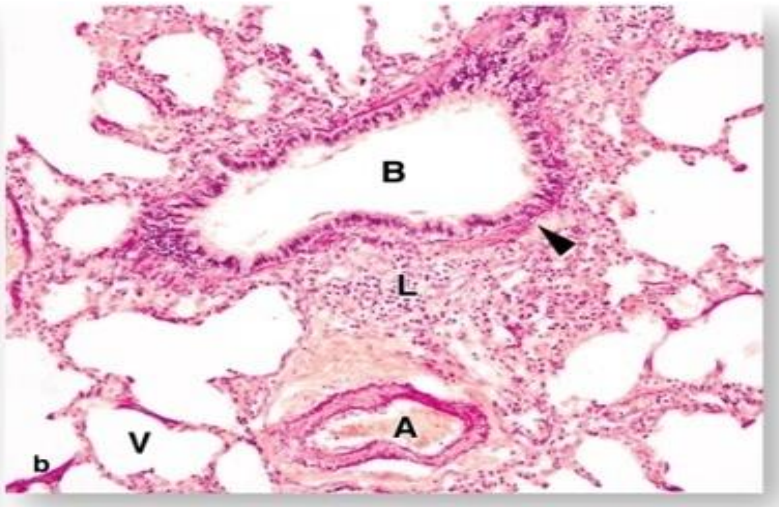
1 - 2 mm more in diameter

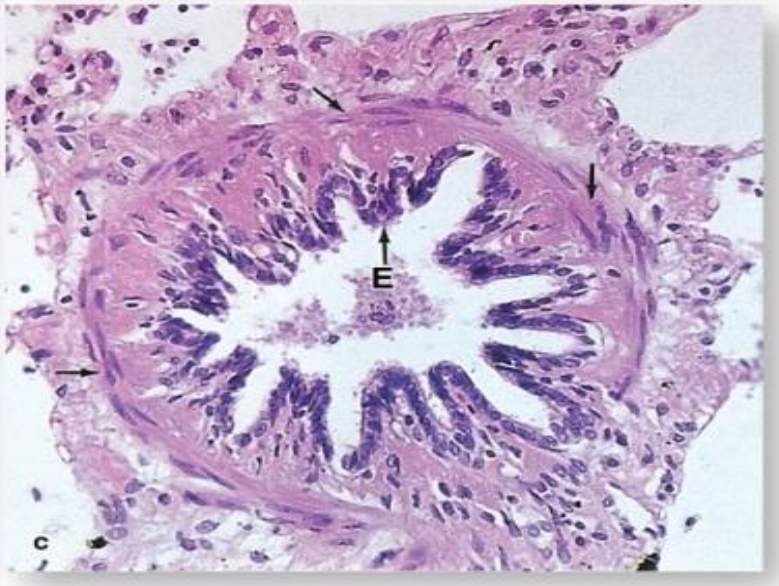


BRONCHIOLES

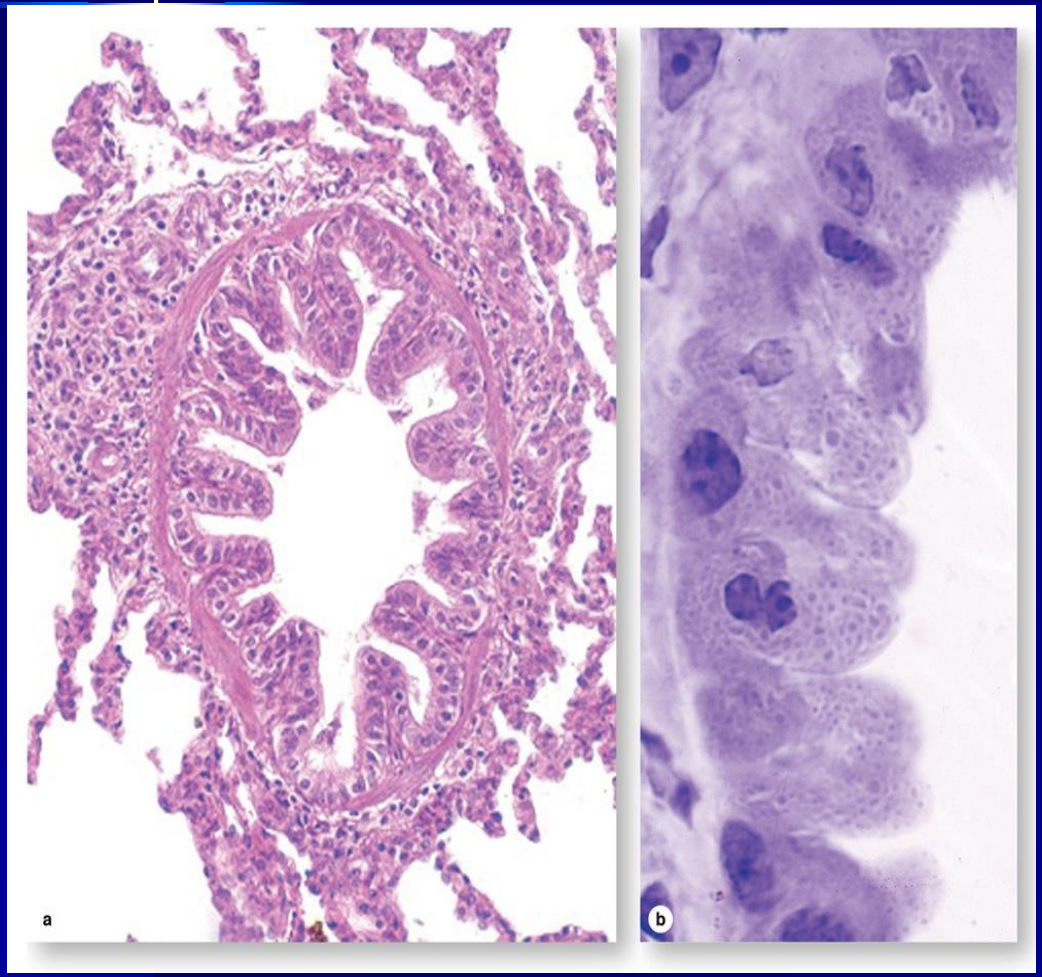
1 mm or less in diameter

- **No cartilage, No glands.**
- **Supported by more elastic CT**
- **Pseudostratified to Simple ciliated columnar or cuboidal epithelium**
- **Goblet cells disappeared.**
- **Smooth muscles surrounded**
- **Folded respiratory epithelium**



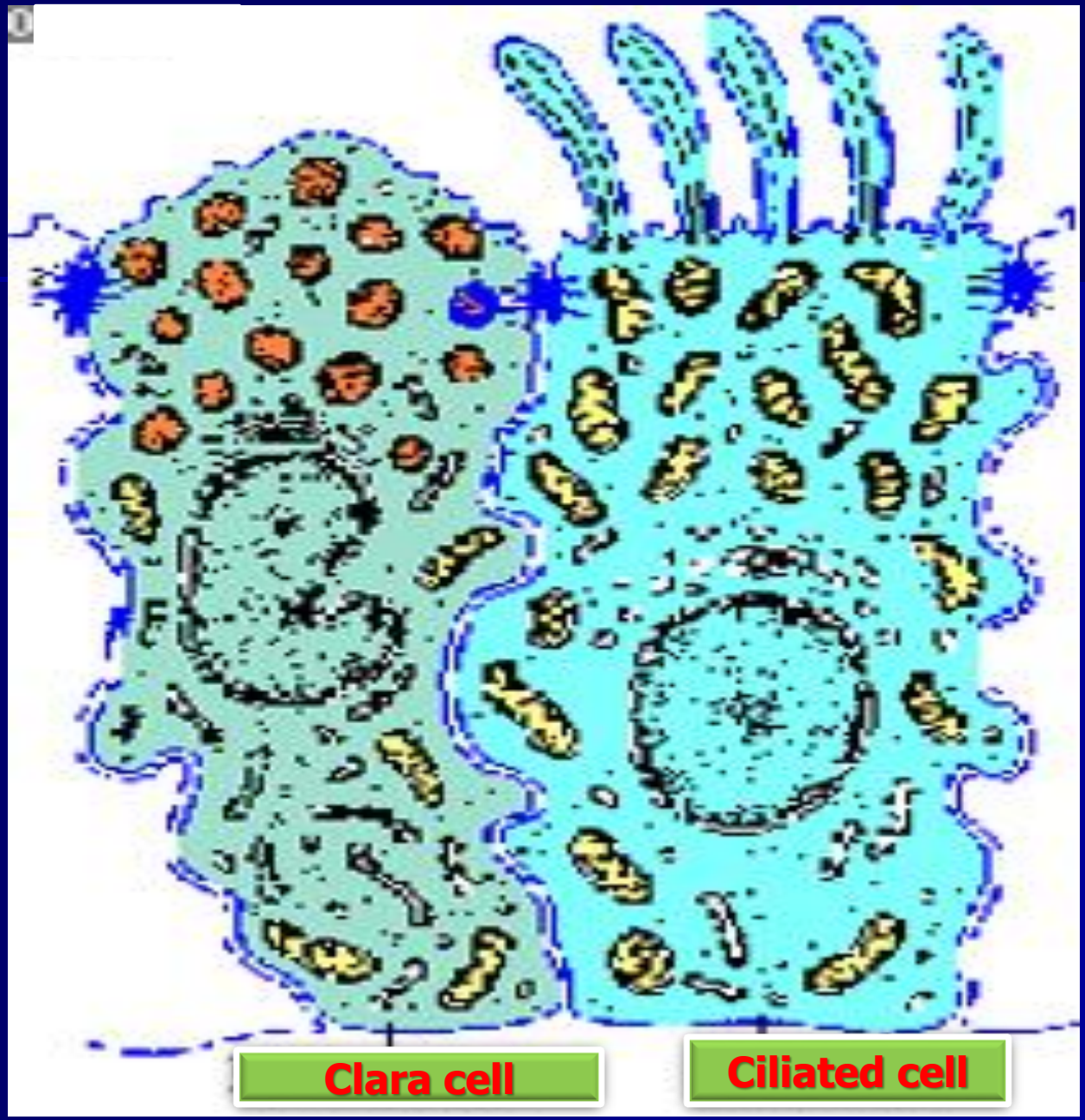


TERMINAL BRONCHIOLE & CLARA CELLS

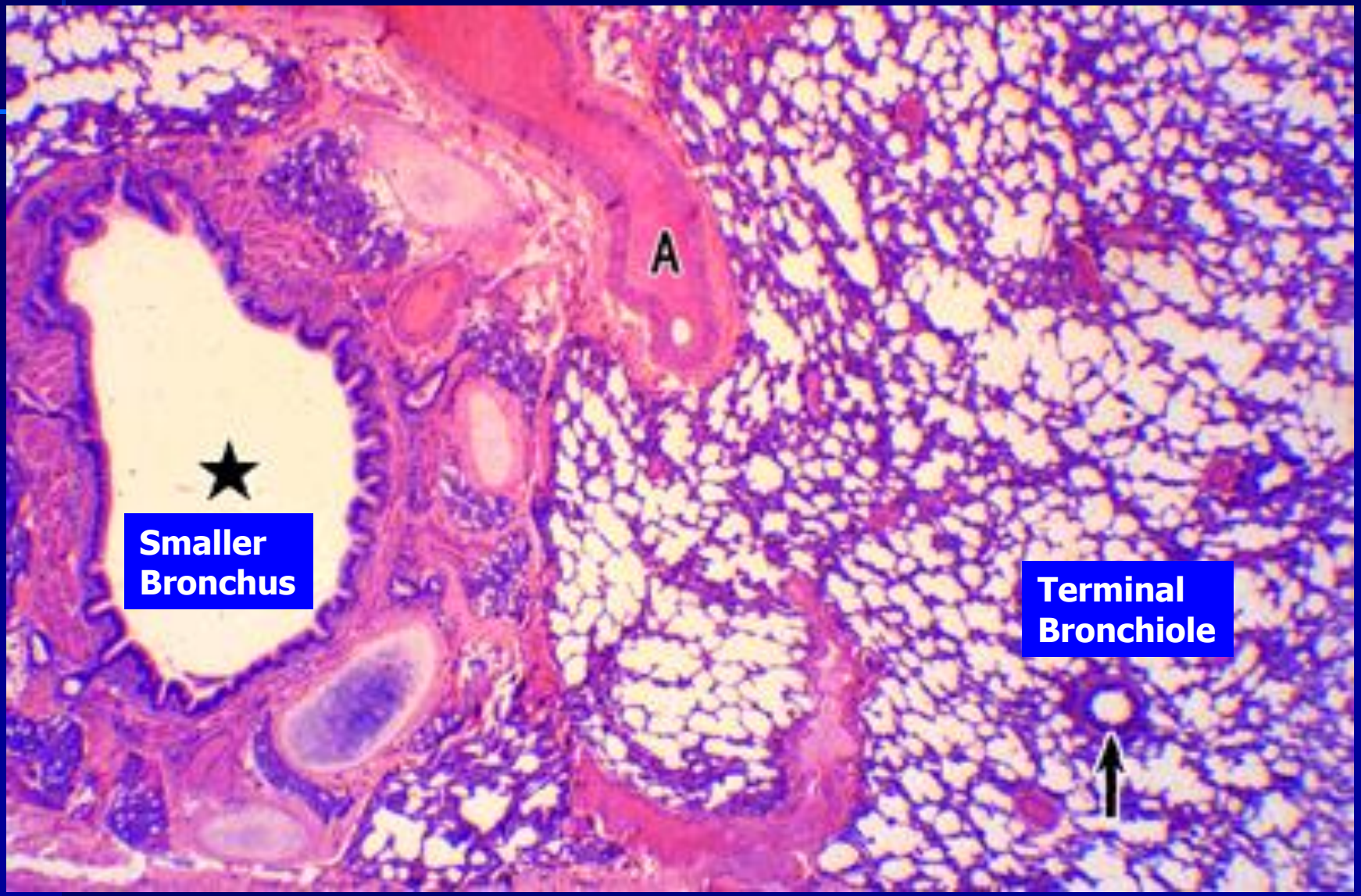


- 1 mm less in diameter
- 1 or 2 layers of smooth muscle cells
- **Nonciliated cuboidal cells (Clara cells)**
  - **Have granules in apical** cytoplasm **like goblet cells**
  - Secrete **surfactant components** to **control** surface **tension**
  - Play various **defensive roles** by producing **enzymes.**
  - **Stem cell**

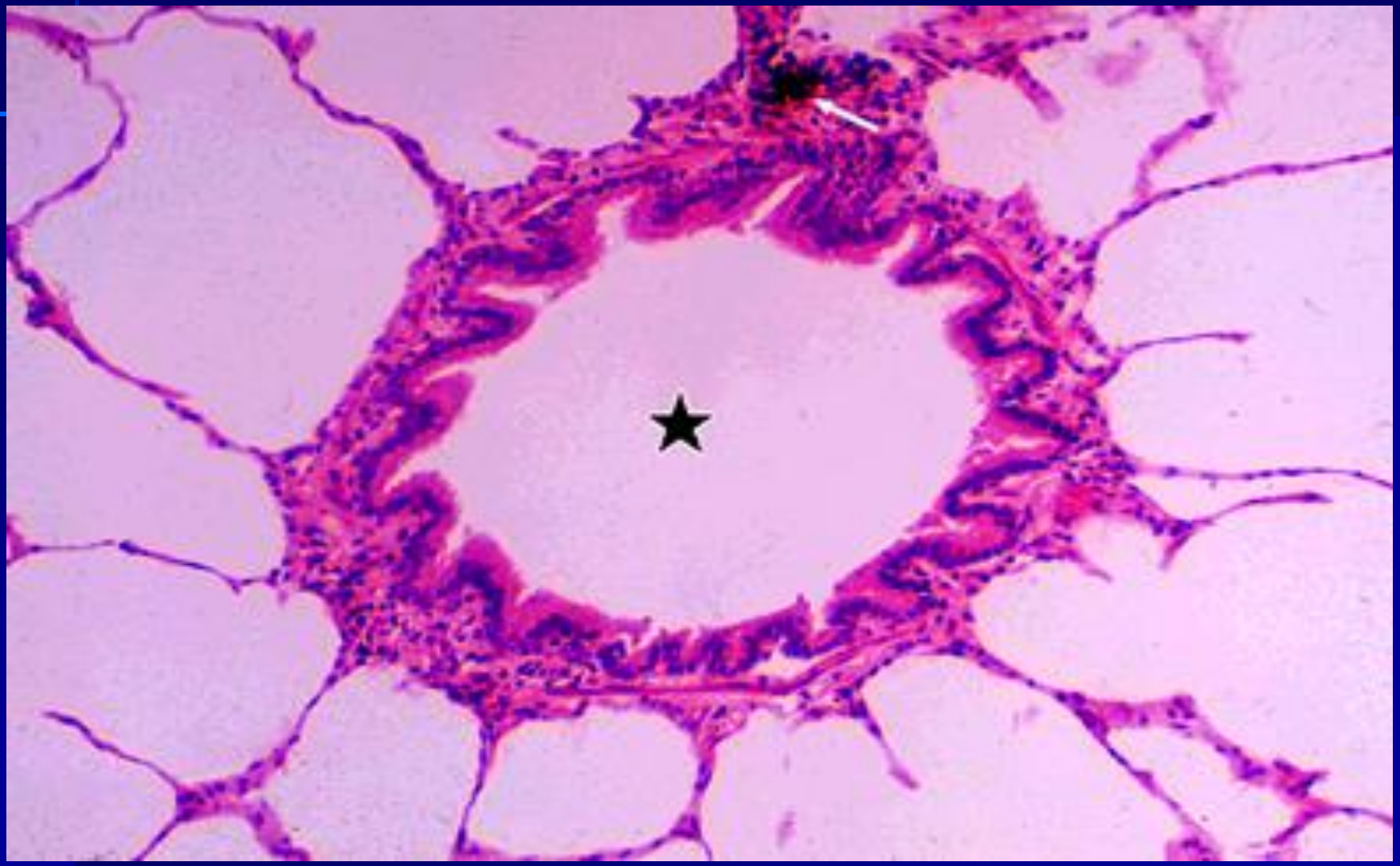
TERMINAL BRONCHIOLE & CLARA CELLS



Human Lung

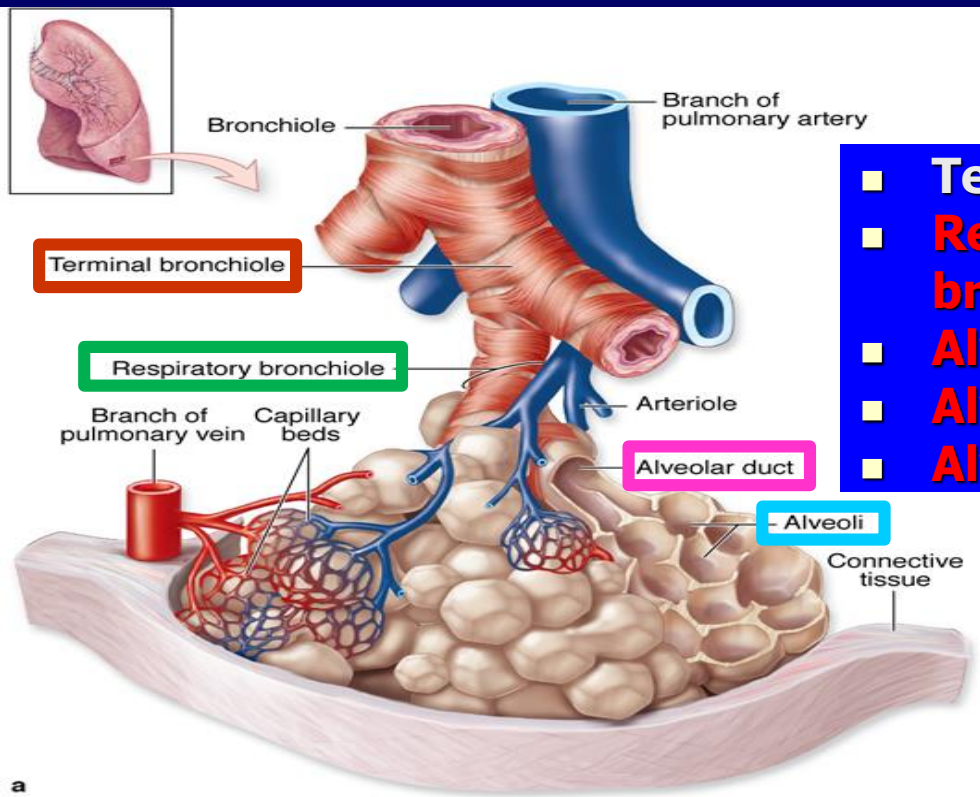


Terminal Bronchiole (human lung)

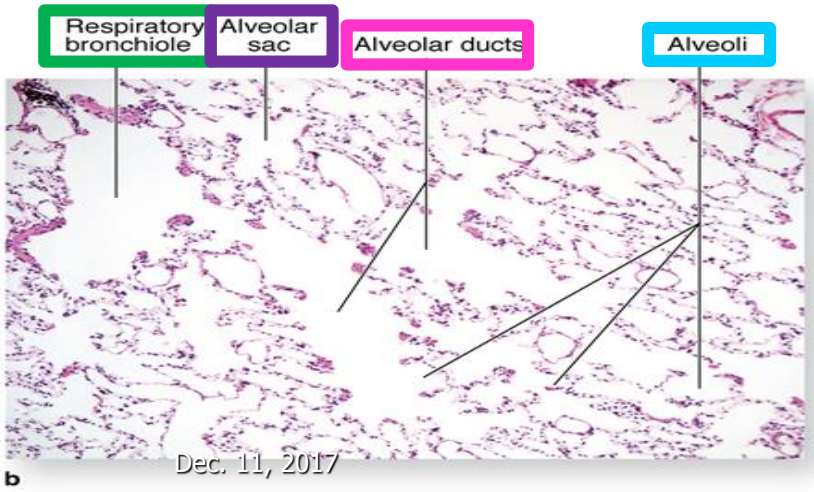


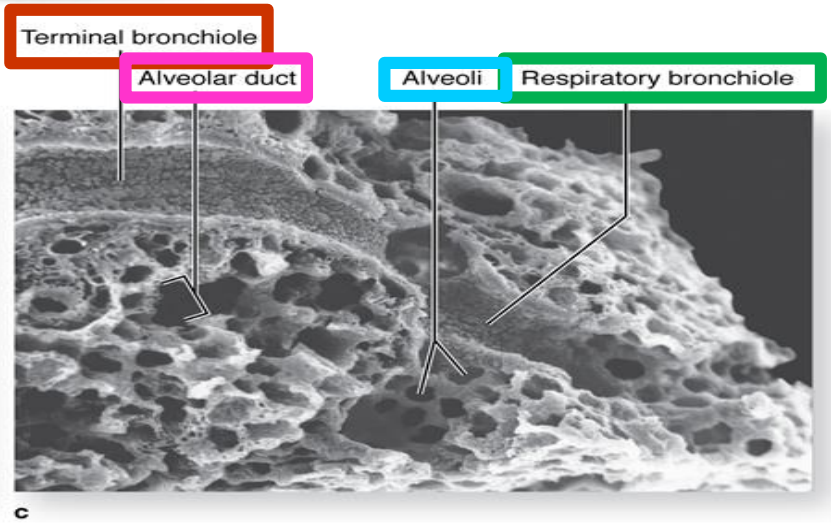
Summary of changing structure in conducting portion (PBi-SBi-TBi-SmBi-B-TB)

- Smaller in diameter
- Thinner in wall
- Ciliated pseudostratified→ciliated simple→nonciliated simple columnar epithelium
- Goblet cells：many→few→none
- Glands：many→few→none
- Cartilage：many→few→none
- Circular SM：few→many→circular completely

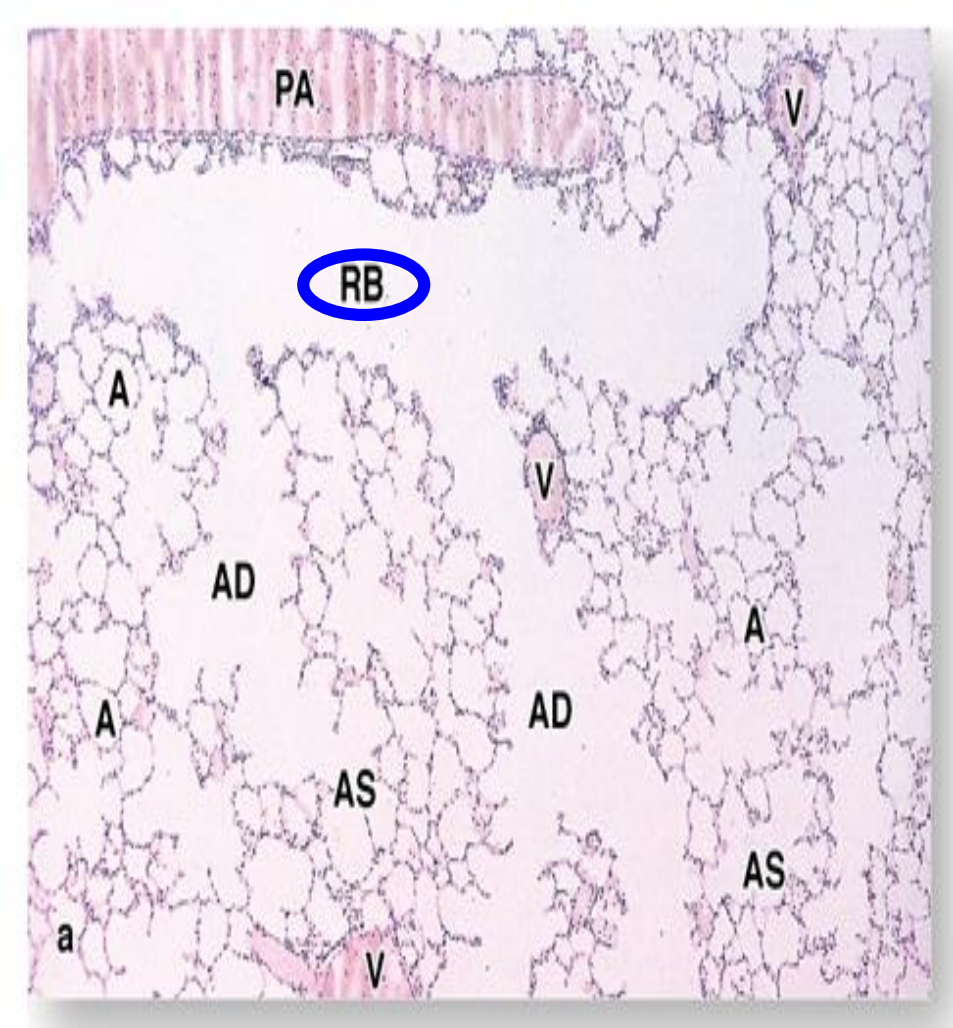


- Terminal Bronchioles
- Respiratory bronchioles
- Alveolar duct
- Alveolar sac
- Alveolar



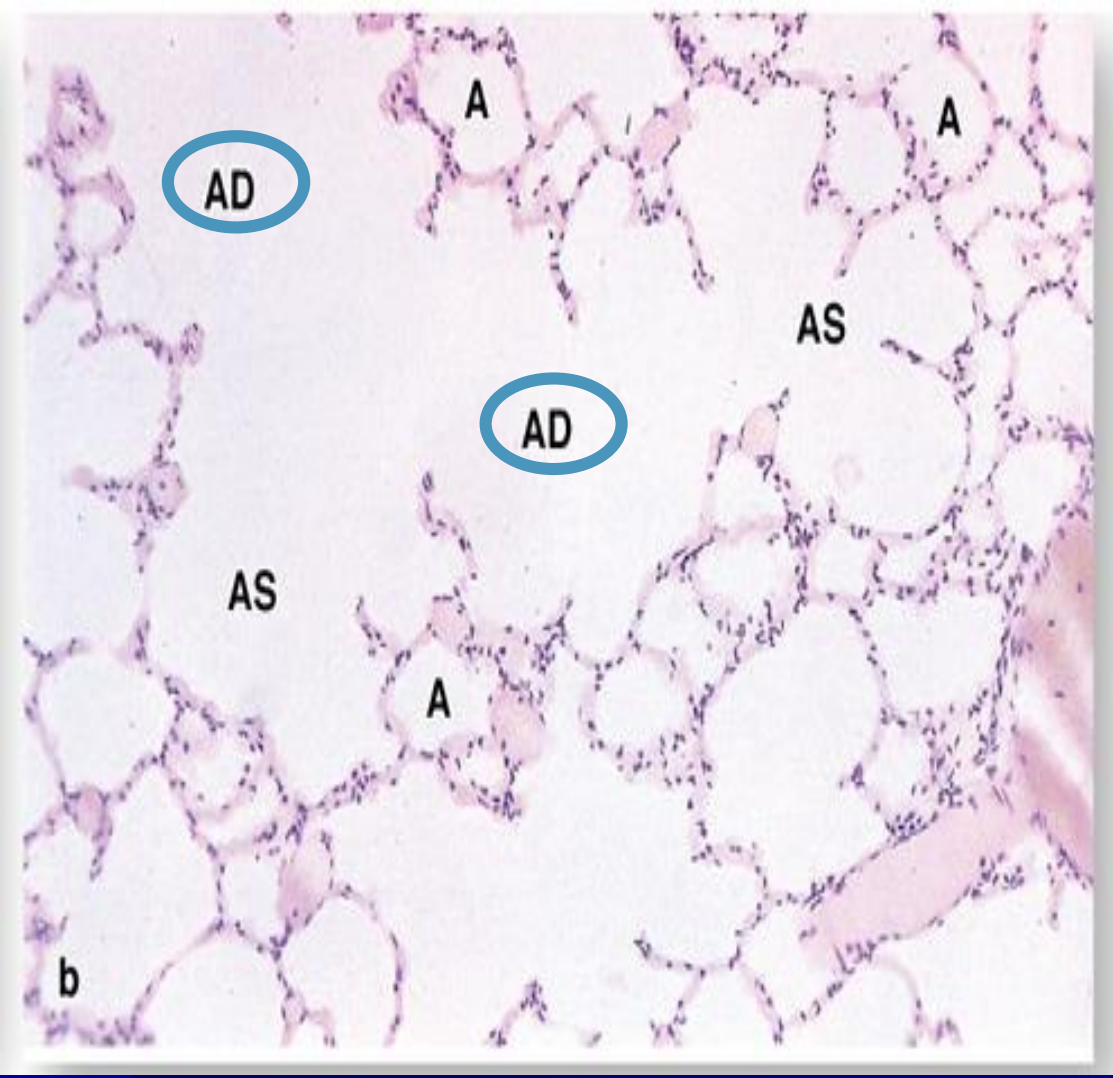


Respiratory bronchioles, RB



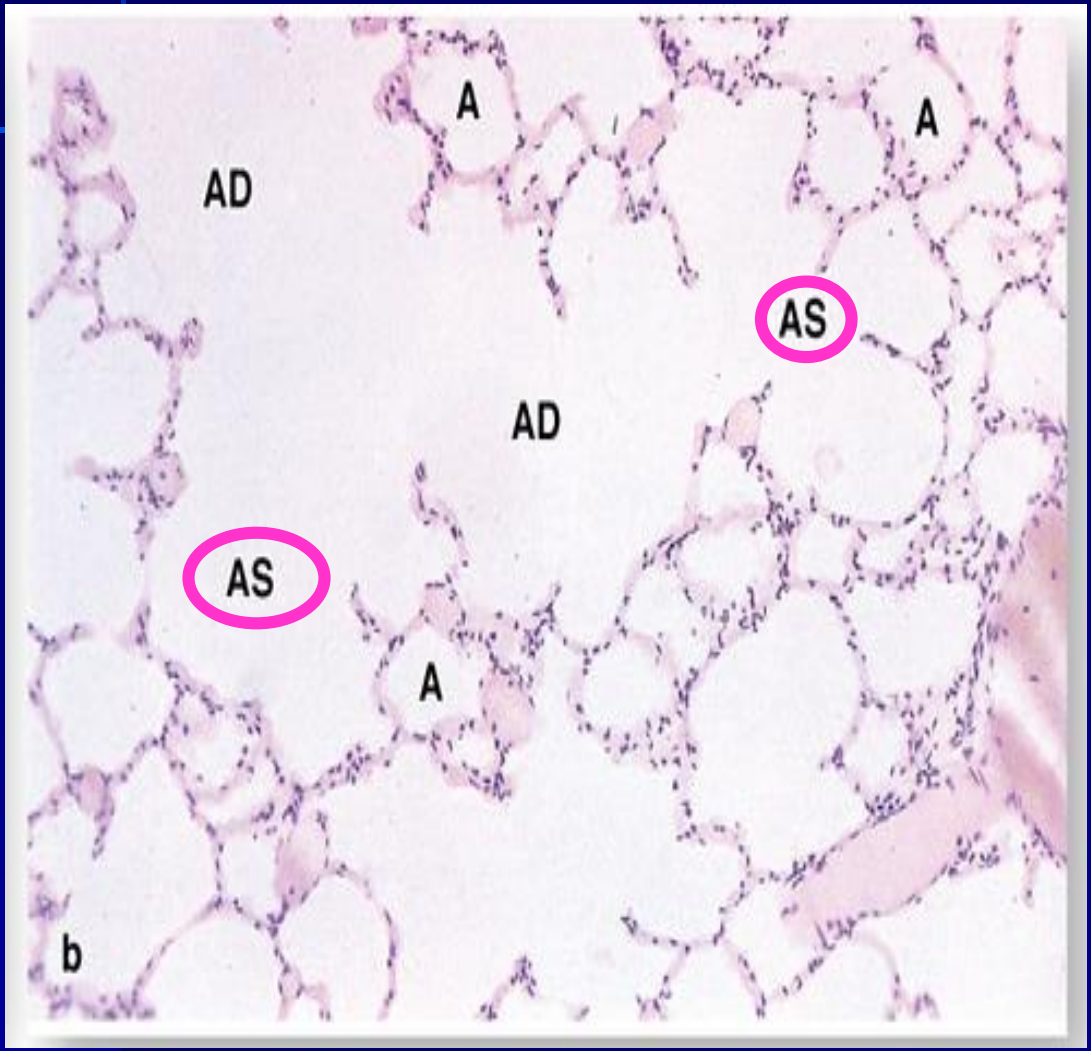
- Have the openings of saclike alveoli
- Lined with ciliated cuboidal epithelial cells and clara cells and squamous alveolar cells (Type I)
- Transition region between conducting and respiratory portions

Alveolar ducts, AD



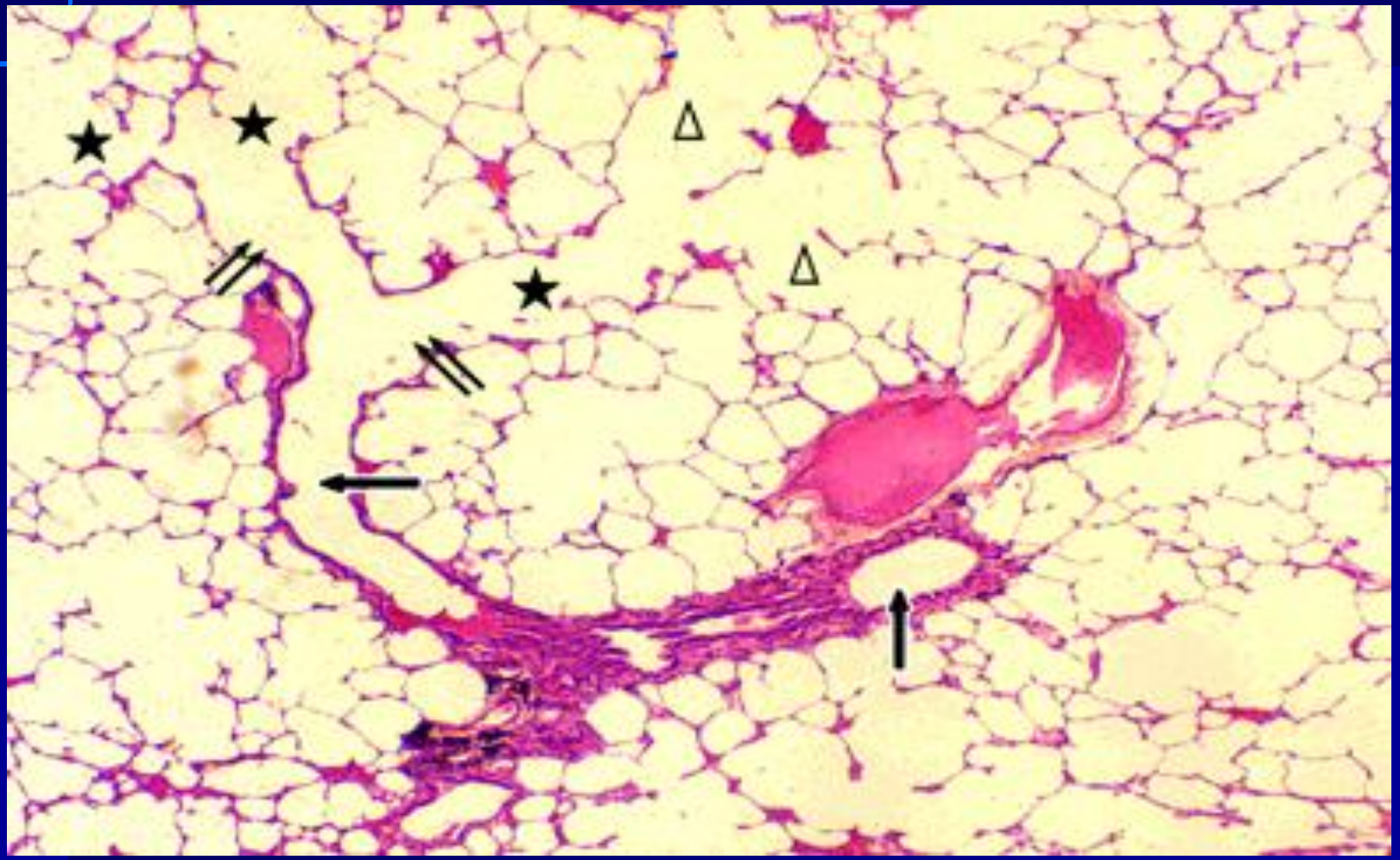
- Lined by **the openings of alveoli**
- Epithelium
  - **squamous alveolar cells**
- Lamina propria
  - **Enlarged knots**: a thin network of **SM surrounding the rim of the alveoli**
  - A matrix of **elastic and collagen fibers**

Alveolar sacs, AS

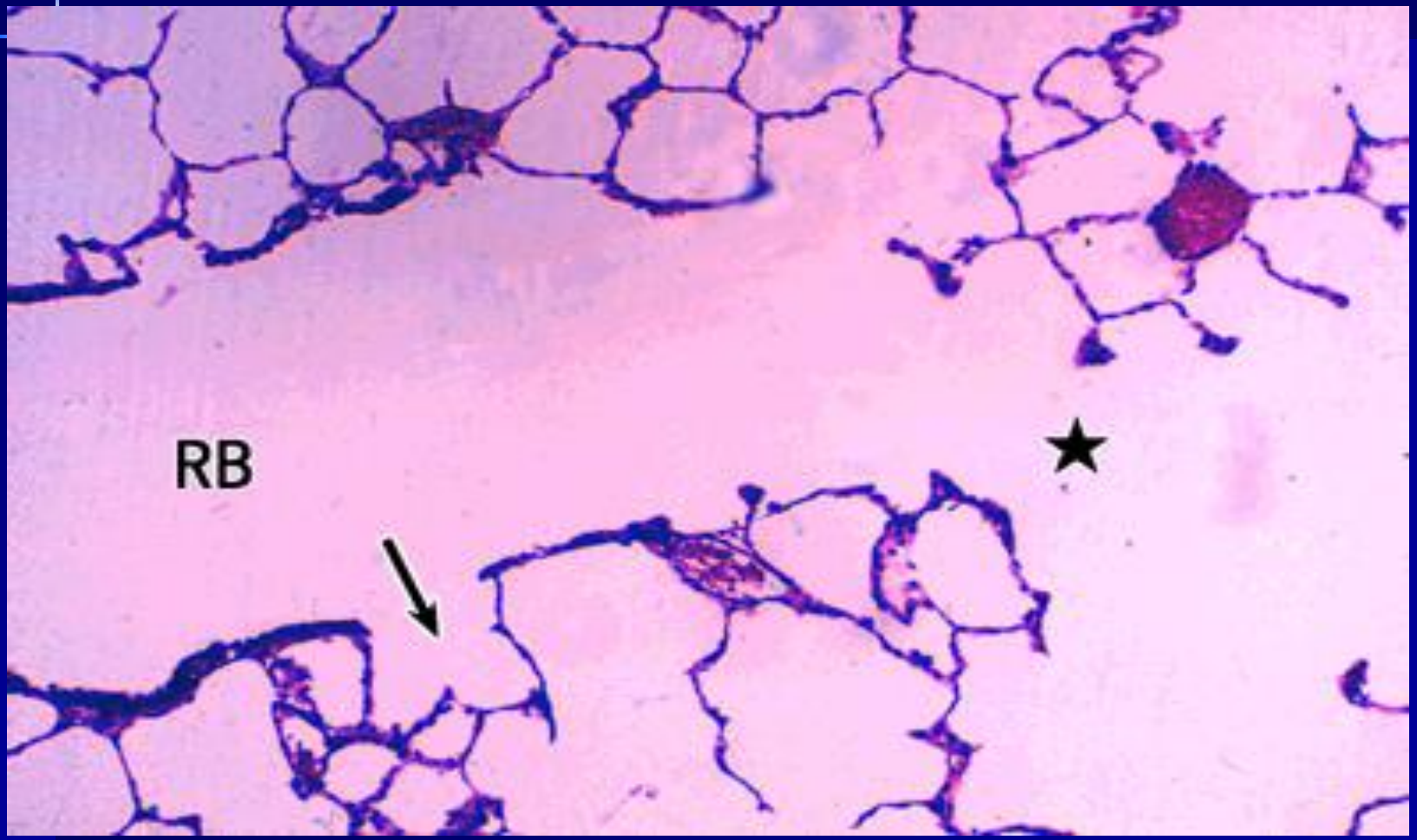


- Be an openings of several alveoli
- Atria of two or more alveolar sacs is opened into AD.
- No SM surrounding the openings of the alveoli EXCEPT Elastic and reticular fibers.

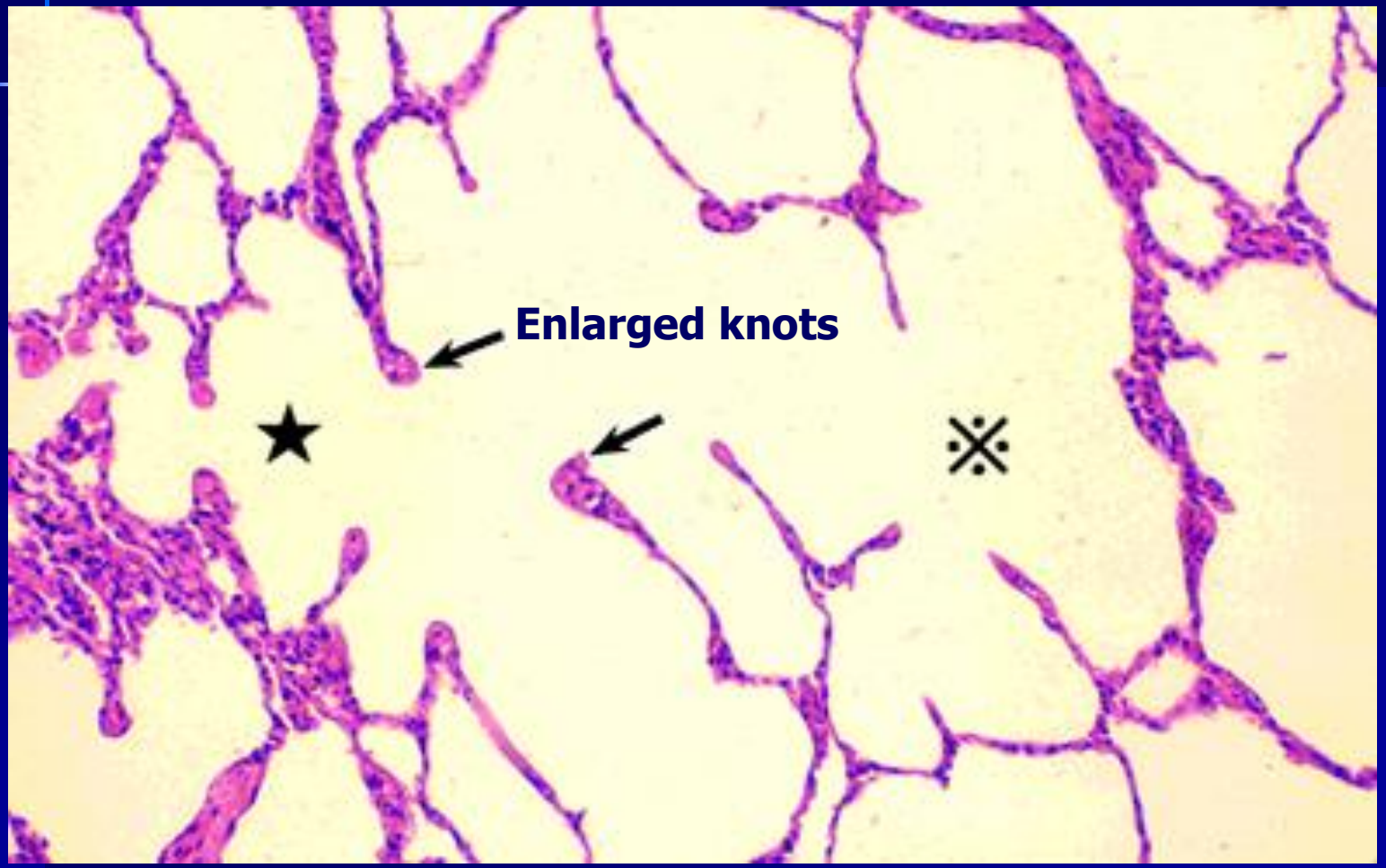
Terminal Bronchiole & Respiratory portion (human lung)



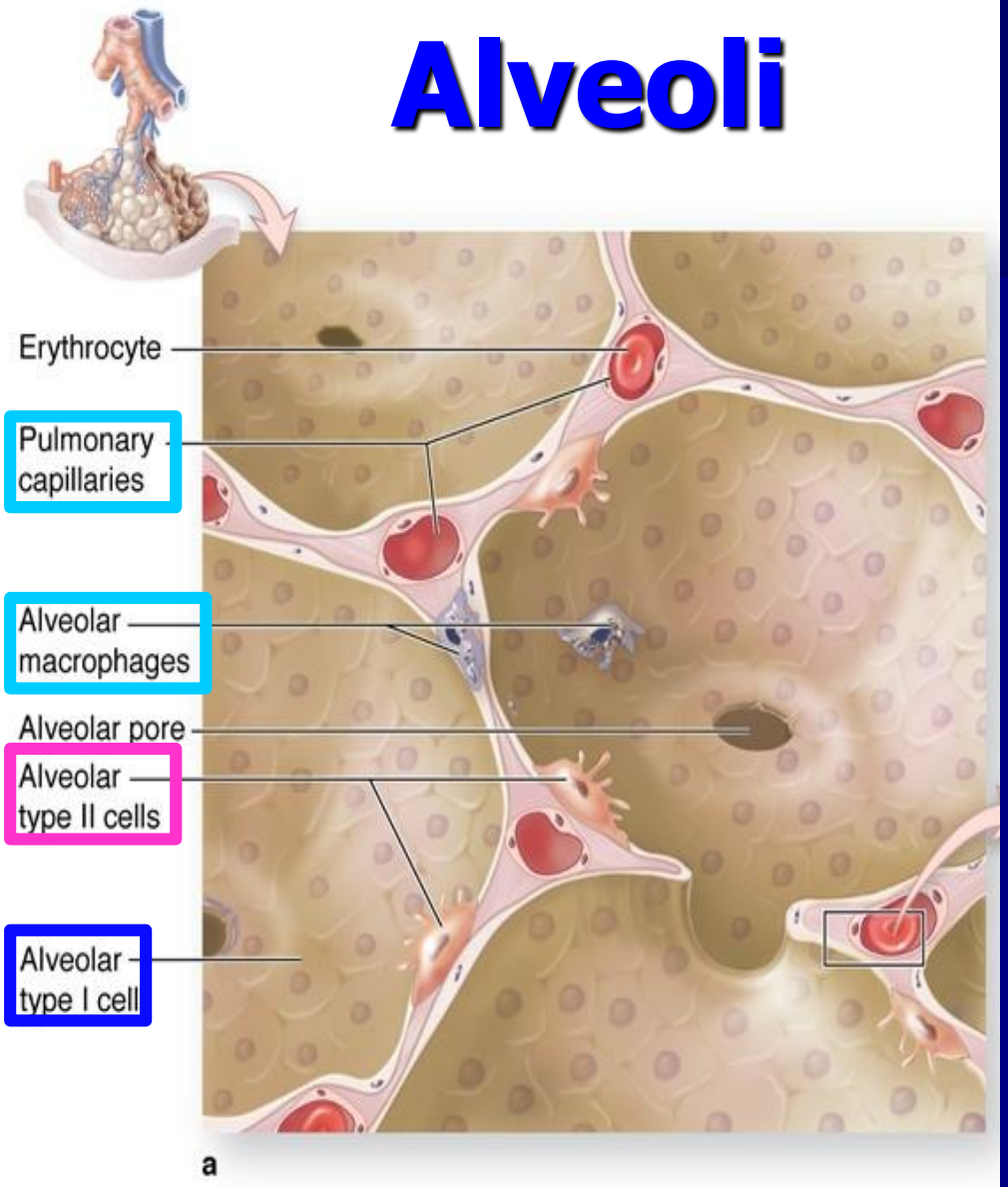
Respiratory Bronchiole & Alveolar Duct (human lung)



Alveolar Duct & Alveolar Sac
(human lung)

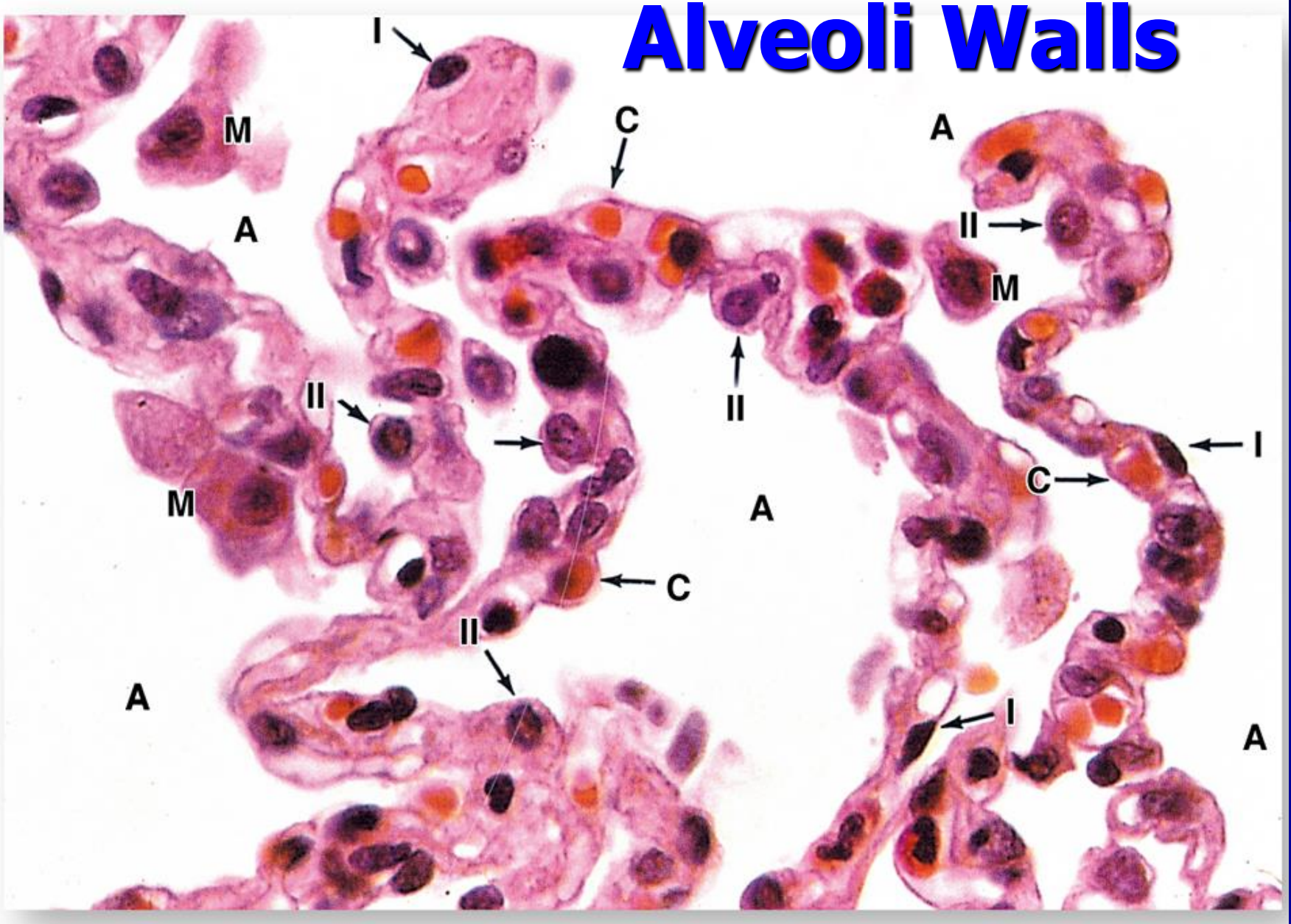


Alveoli



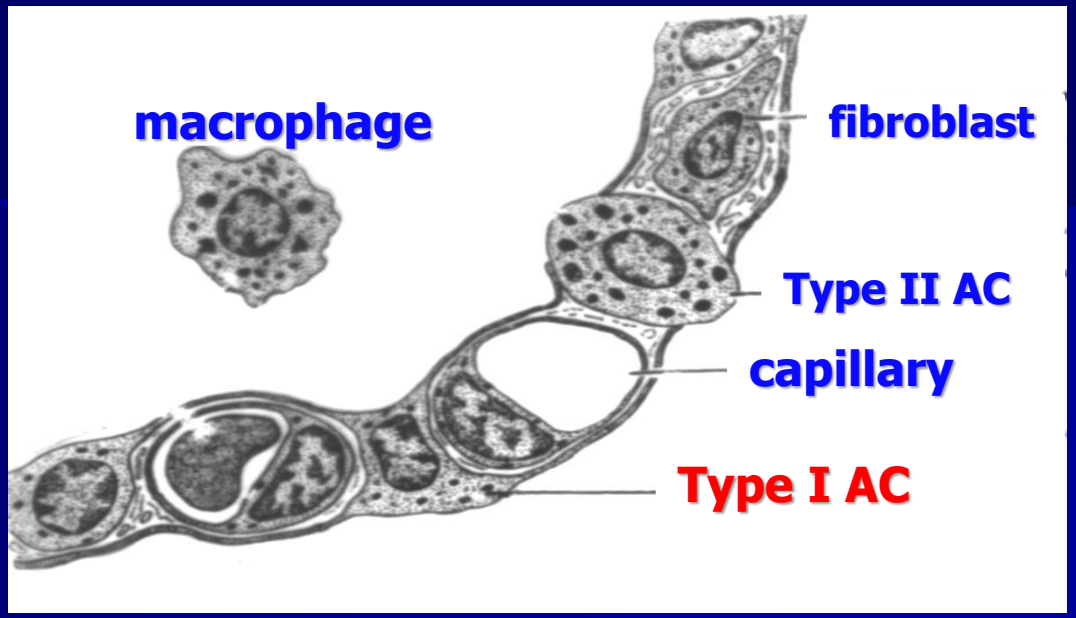
- **Small pocket** opening on one side.
- Region of **gas exchange**
- Lined with simple squamous **alveolar cells**
  - **Type I**
  - **Type II**
- **Inter-alveolar septum**
  - Capillary
  - **Macrophage**
  - Elastic & collagen fibers

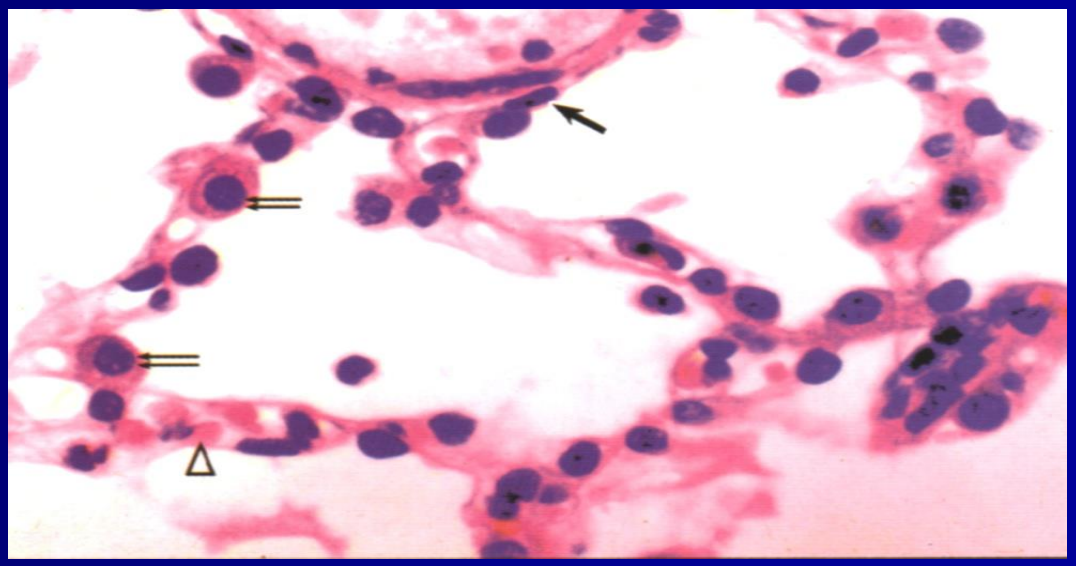
Alveoli Walls



Type I alveolar cells (↑)

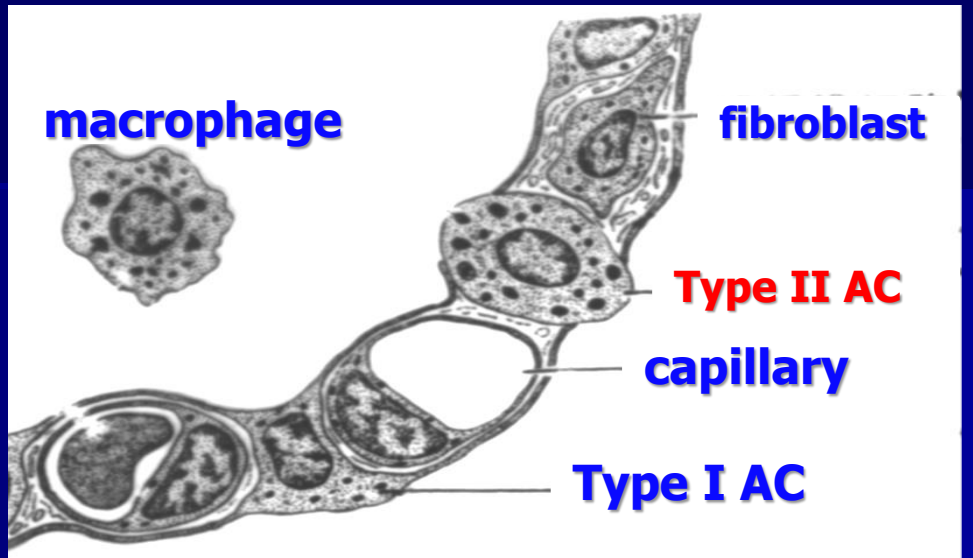
- Also called Type I **pneumocytes** or **squamous** alveolar cells
- **Covered 97%** of the alveolar surface
- **Lined with surfactant**
- **Organelles grouped** around the nucleus **EXCEPT pinocytotic vesicles**
- **Occluding (Tight) junction** sealed

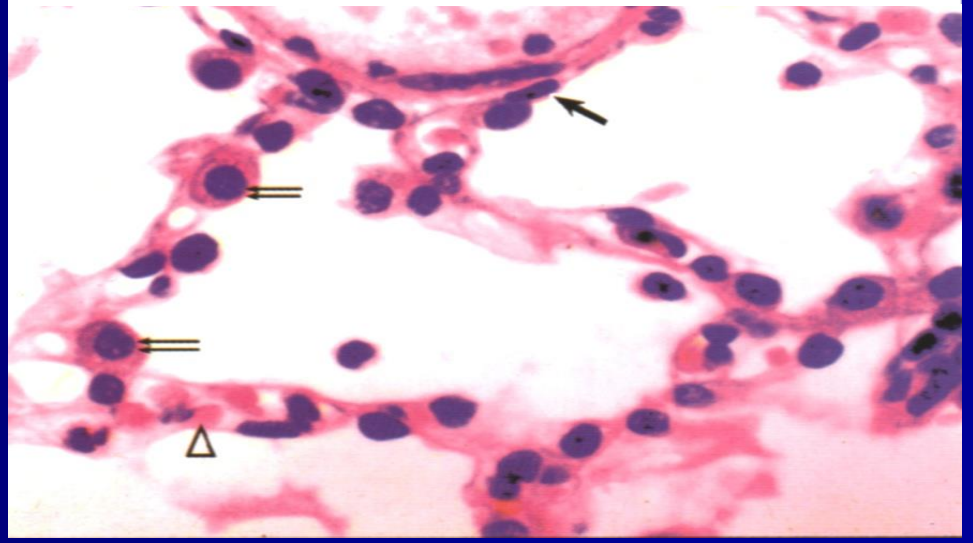




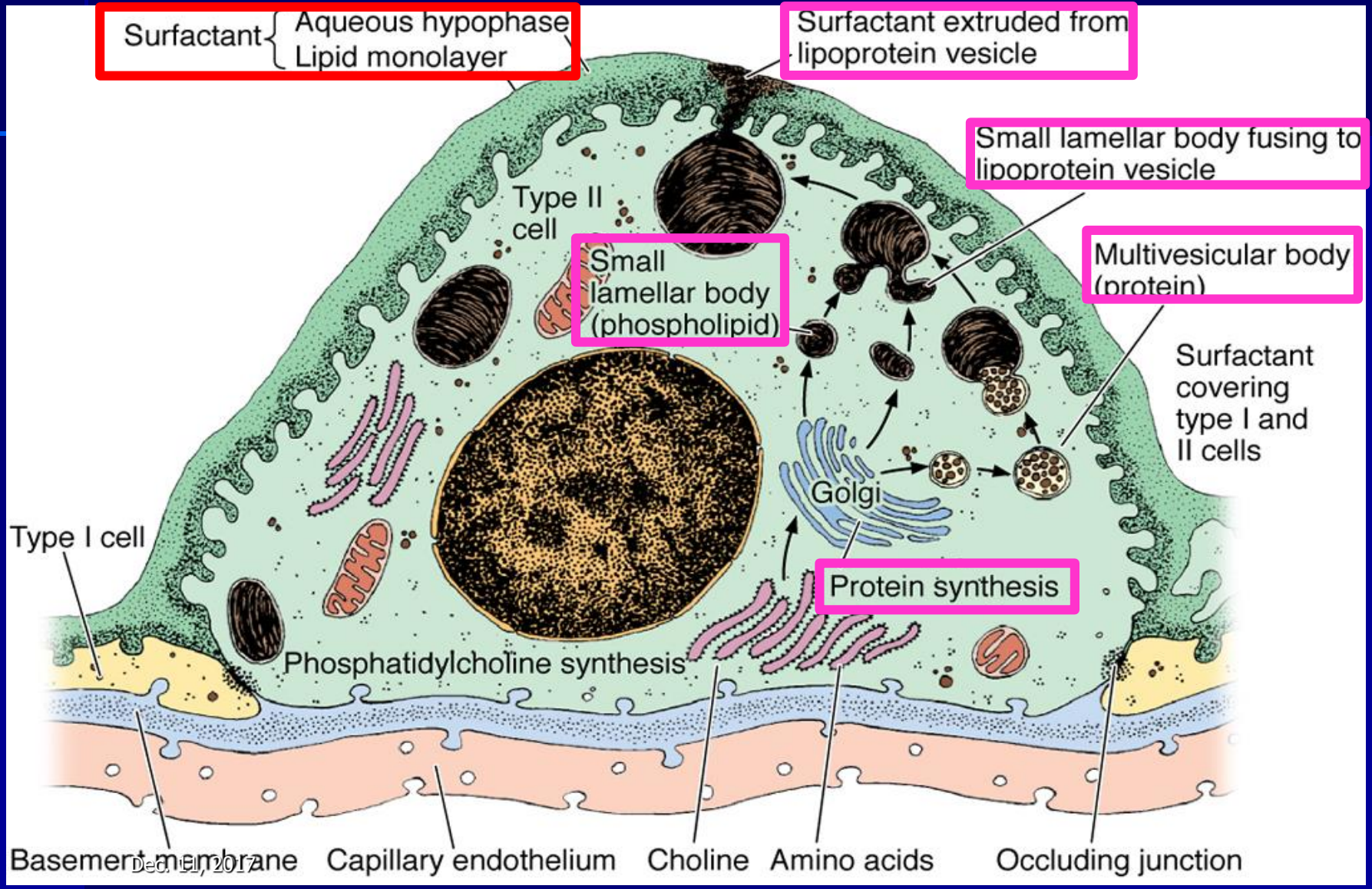
Type II alveolar cells (↑↑)

- Also called Type II pneumocytes
- Covered 3% of the alveolar surface by interspersing among Type I pneumocytes
- Rounded cells with many lamellar bodies
- Synthesis and release the surfactant from the lamellar bodies at the apical surface of cells
- Replace themselves and Type I AC by mitosis
- Having occluding & desmosomal junction

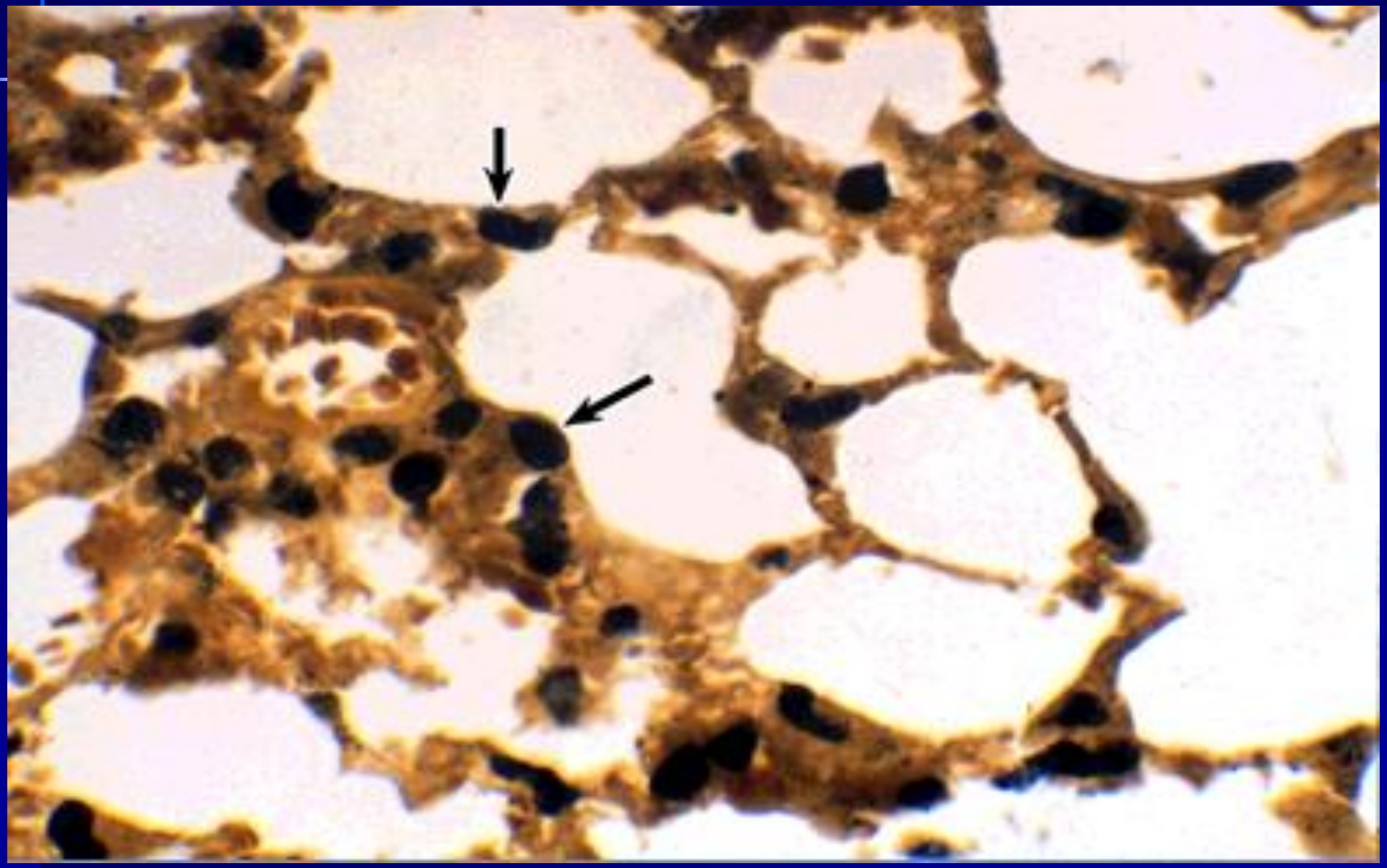


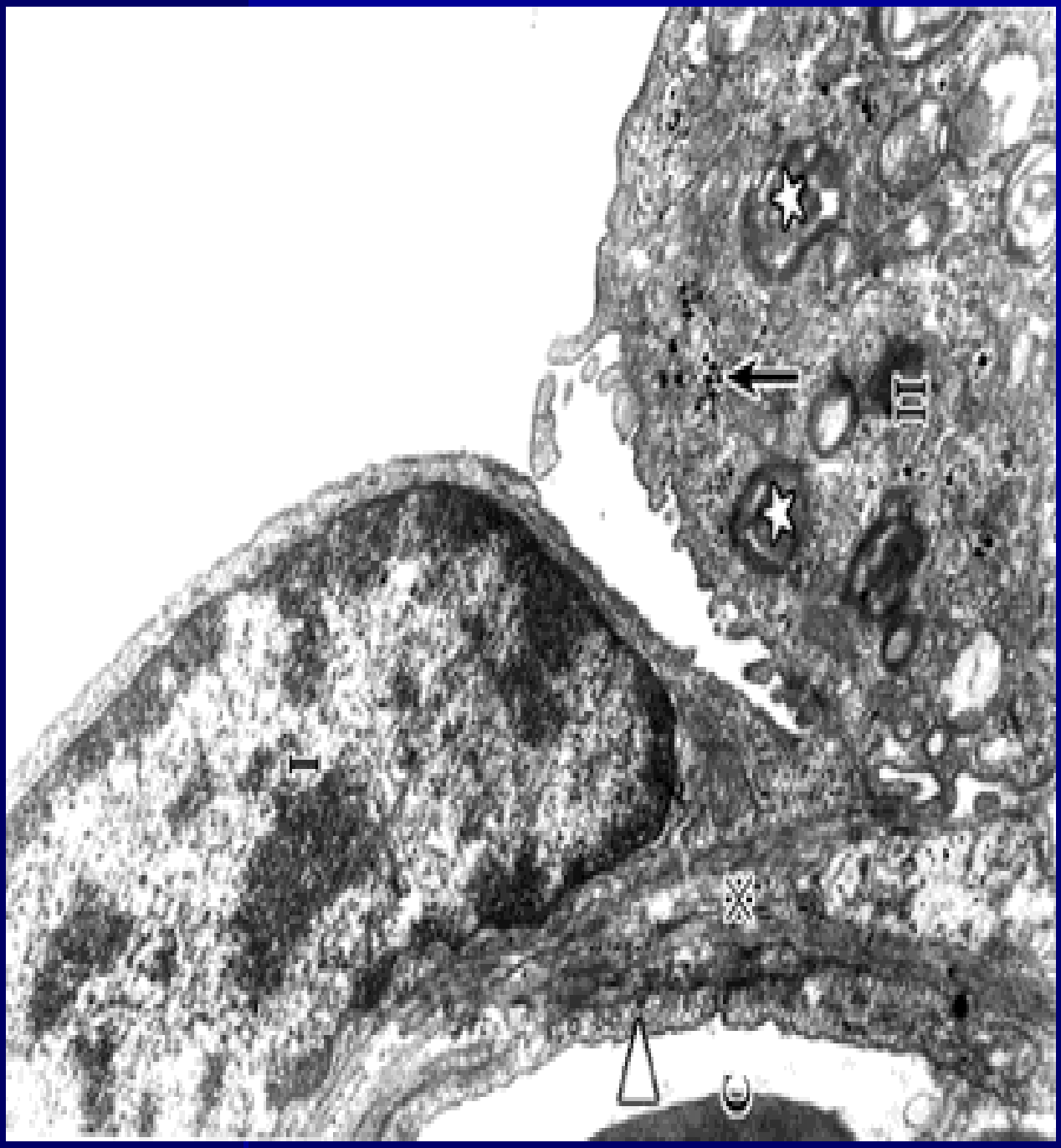


Type II alveolar cell function



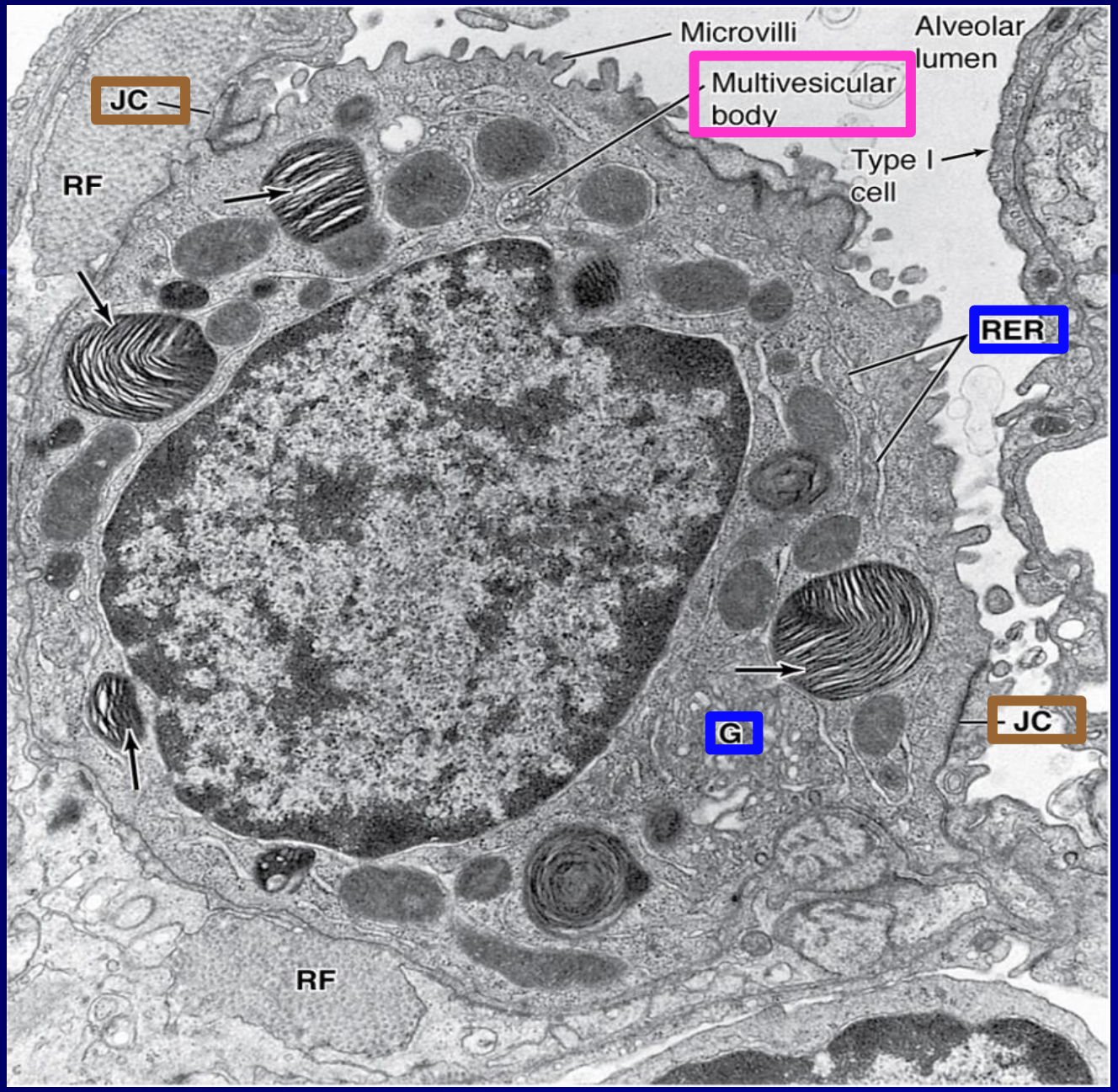
Human Type II Alveolar Cells (fixed and stained with osmic acid)



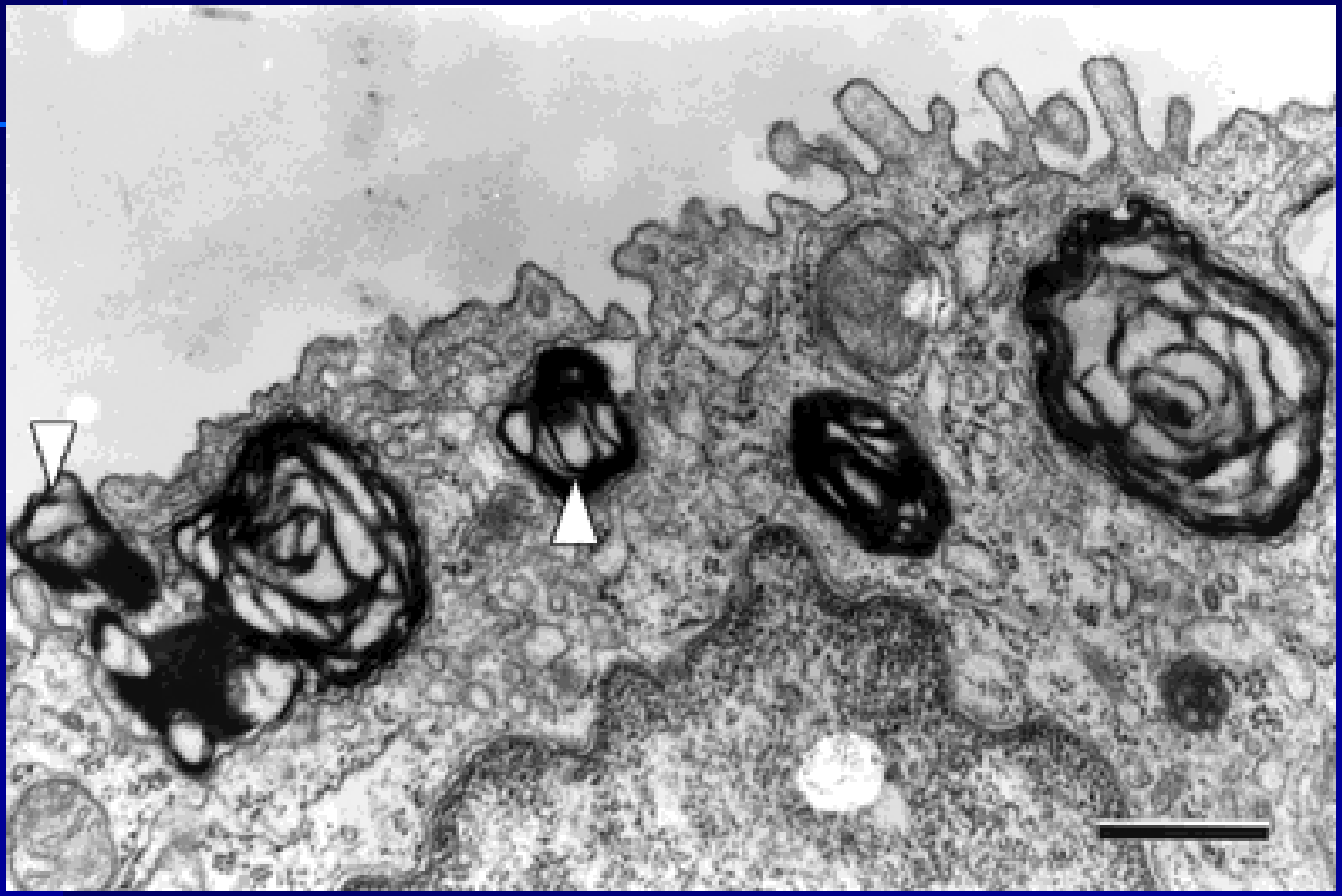


Type I & Type II alveolar cells (monkey lung)

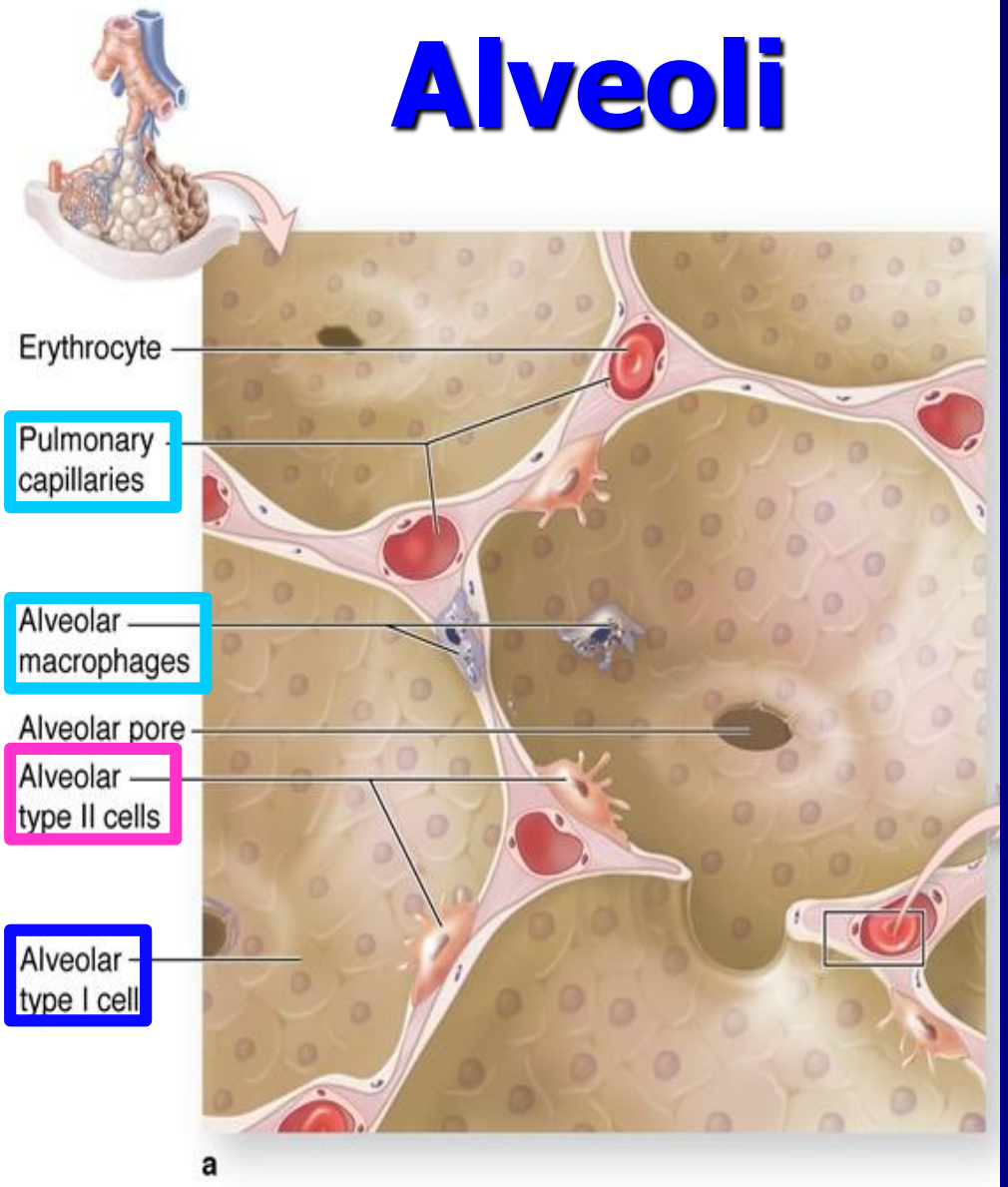
Type II alveolar cells



Human Type II Alveolar Cells

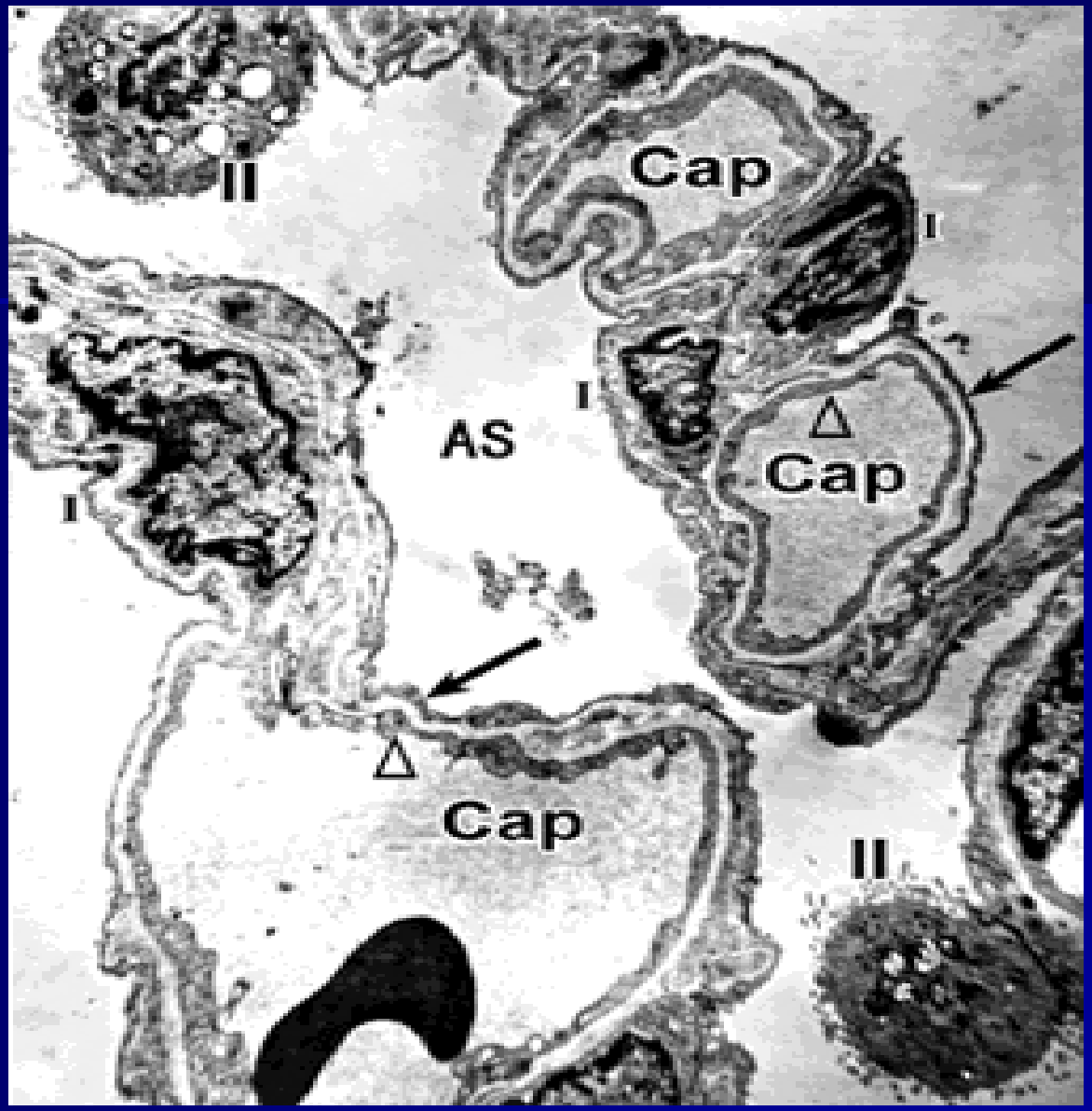


Alveoli

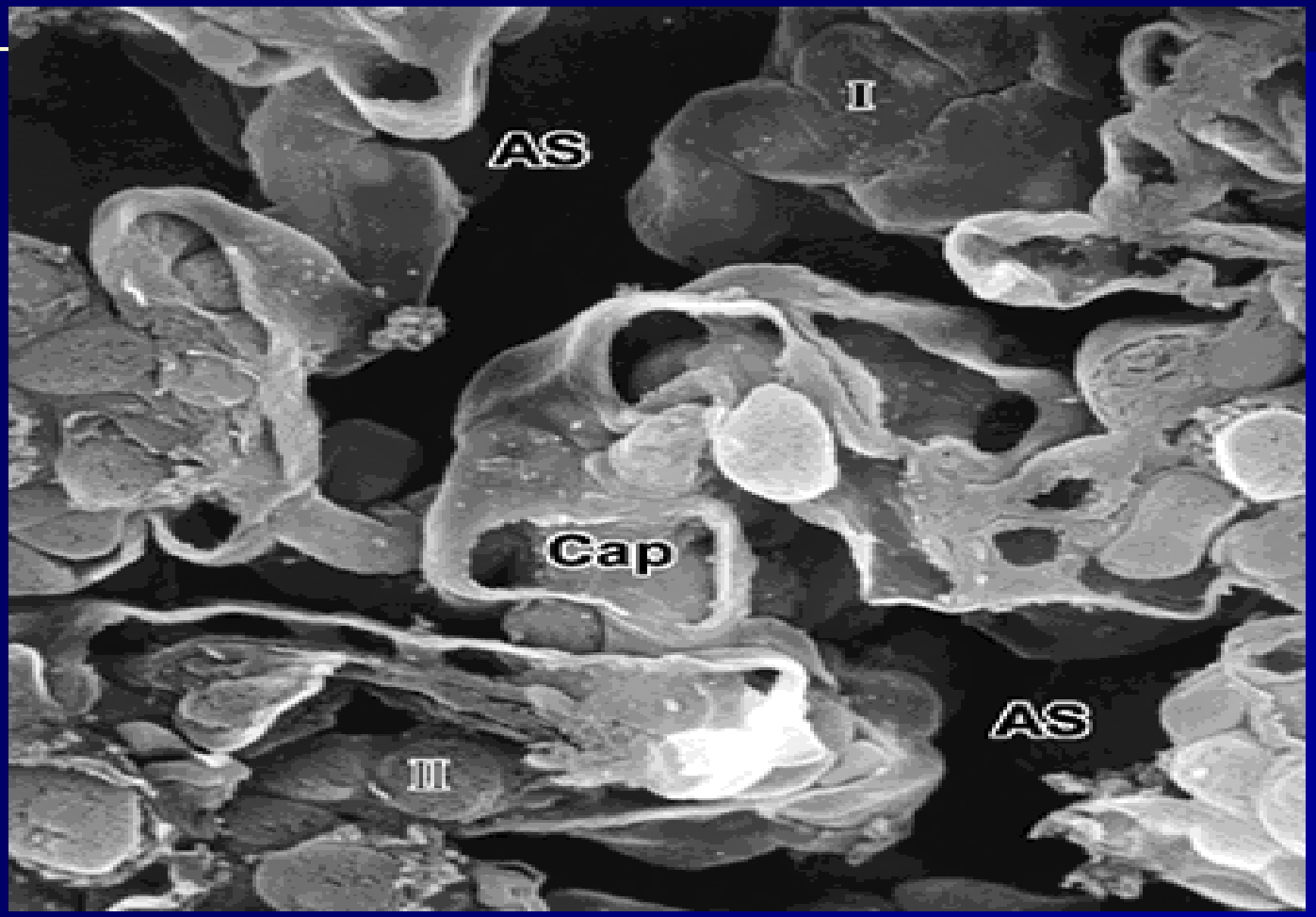


- **Small pocket** opening on one side.
- Region of **gas exchange**
- Lined with simple squamous **alveolar cells**
  - **Type I**
  - **Type II**
- **Inter-alveolar septum**
  - Capillary
  - **Macrophage**
  - Elastic & collagen fibers

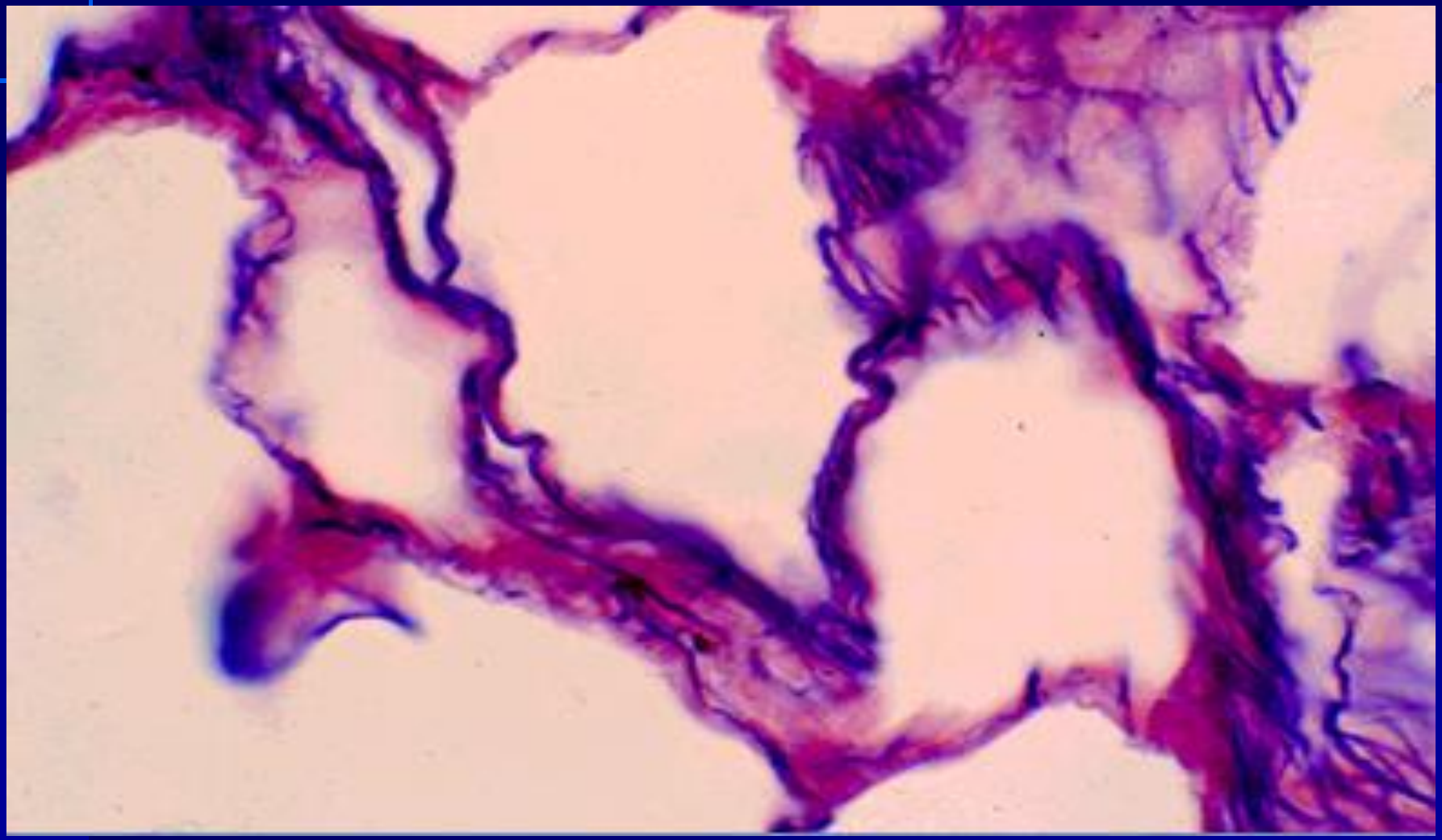
Alveolar cells & Alveolar walls



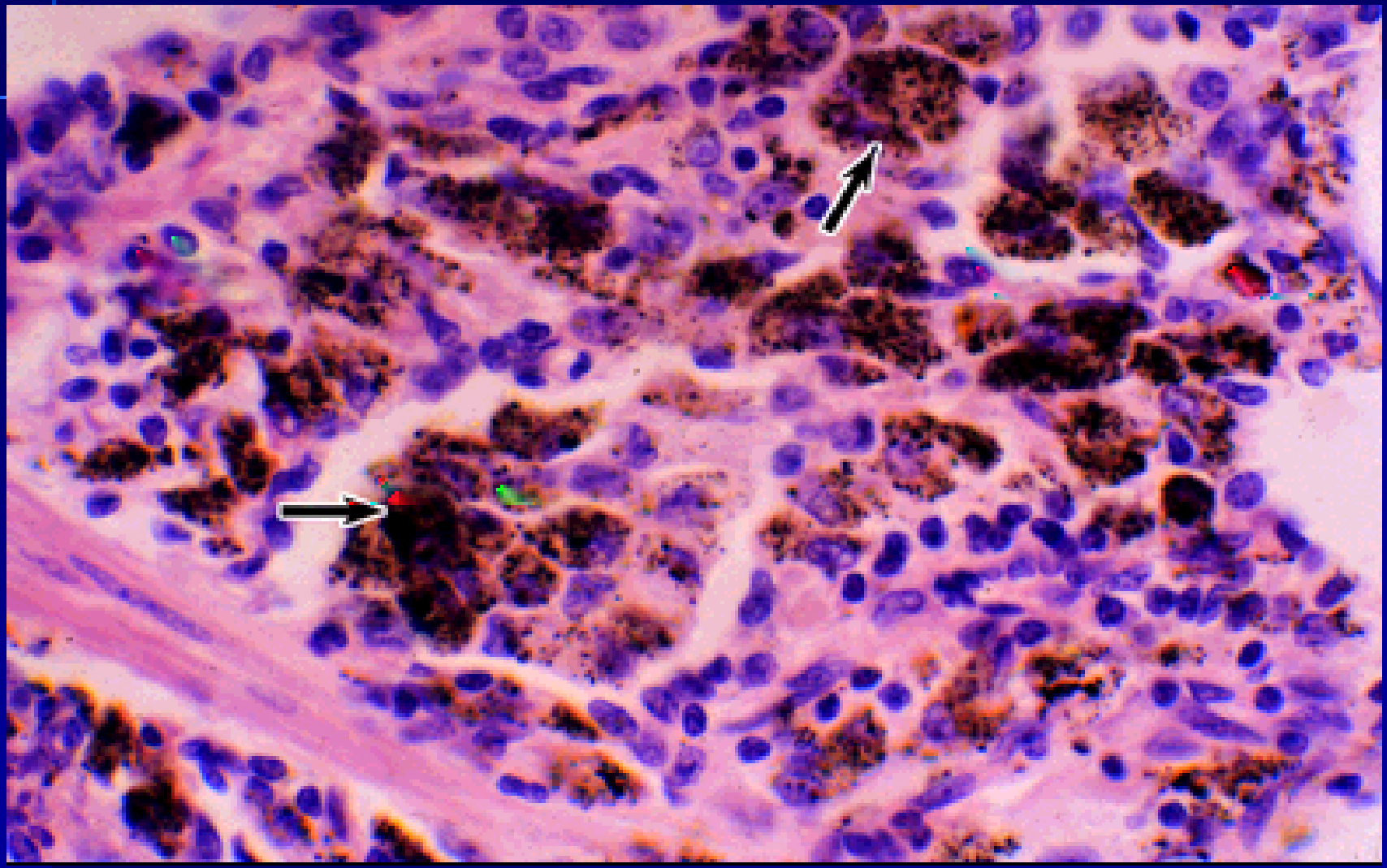
SEM photo of rabbit respiratory portion of lung



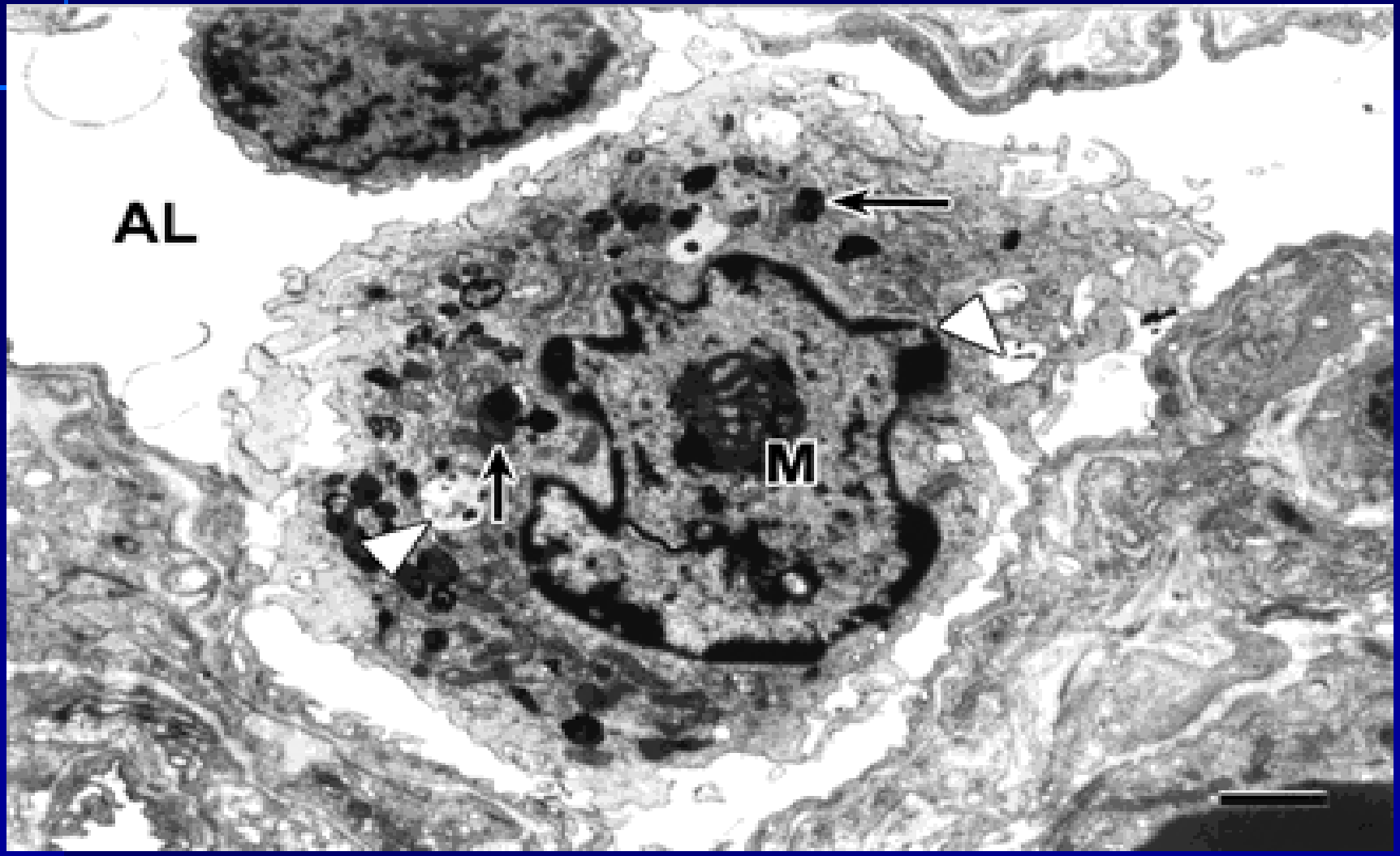
Elastic Fibers in Alveolar Wall
(human lung, Weigert Staining)



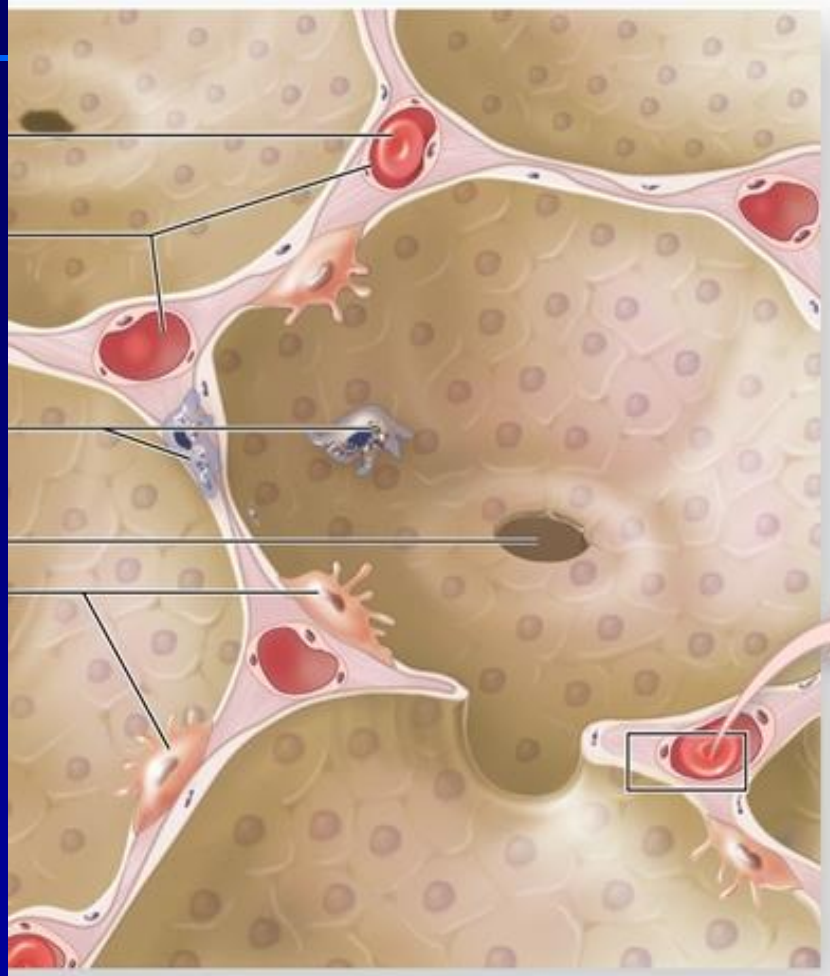
Dust cells in alveolar wall (human lung)

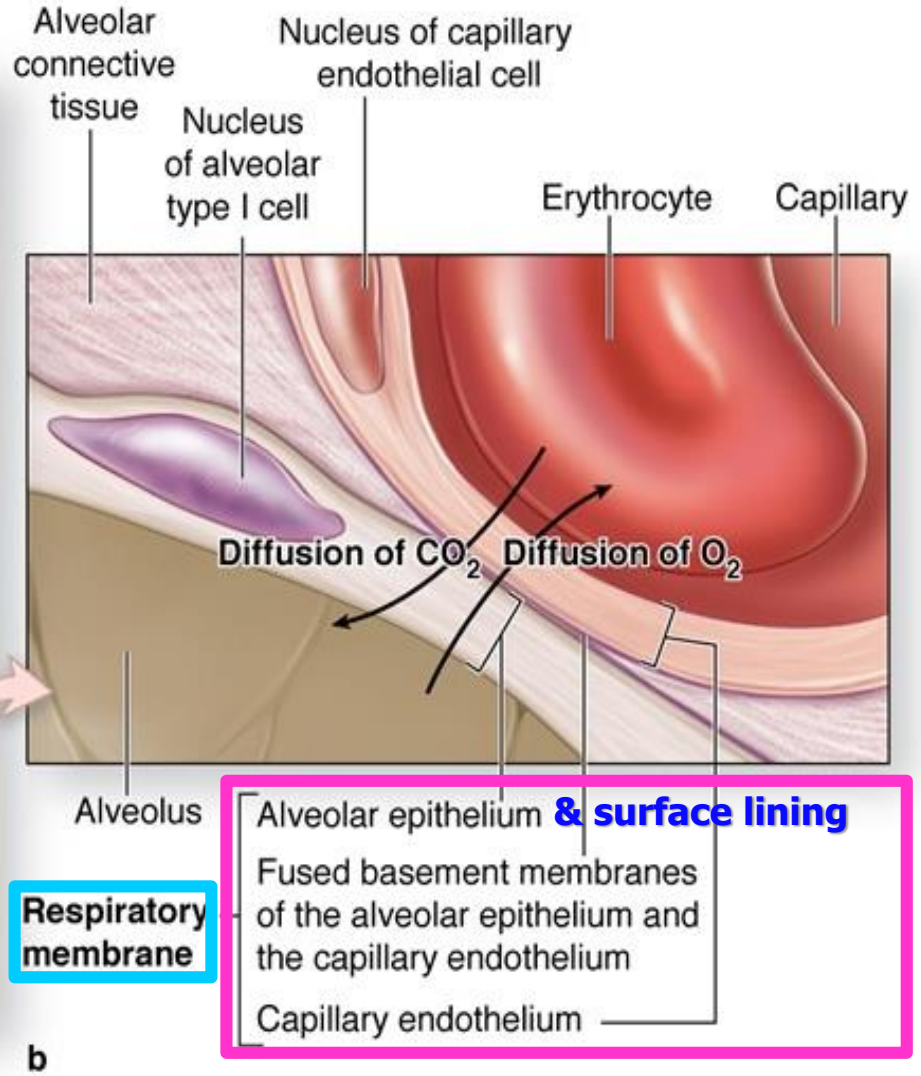


Alveolar Macrophage
(human lung)

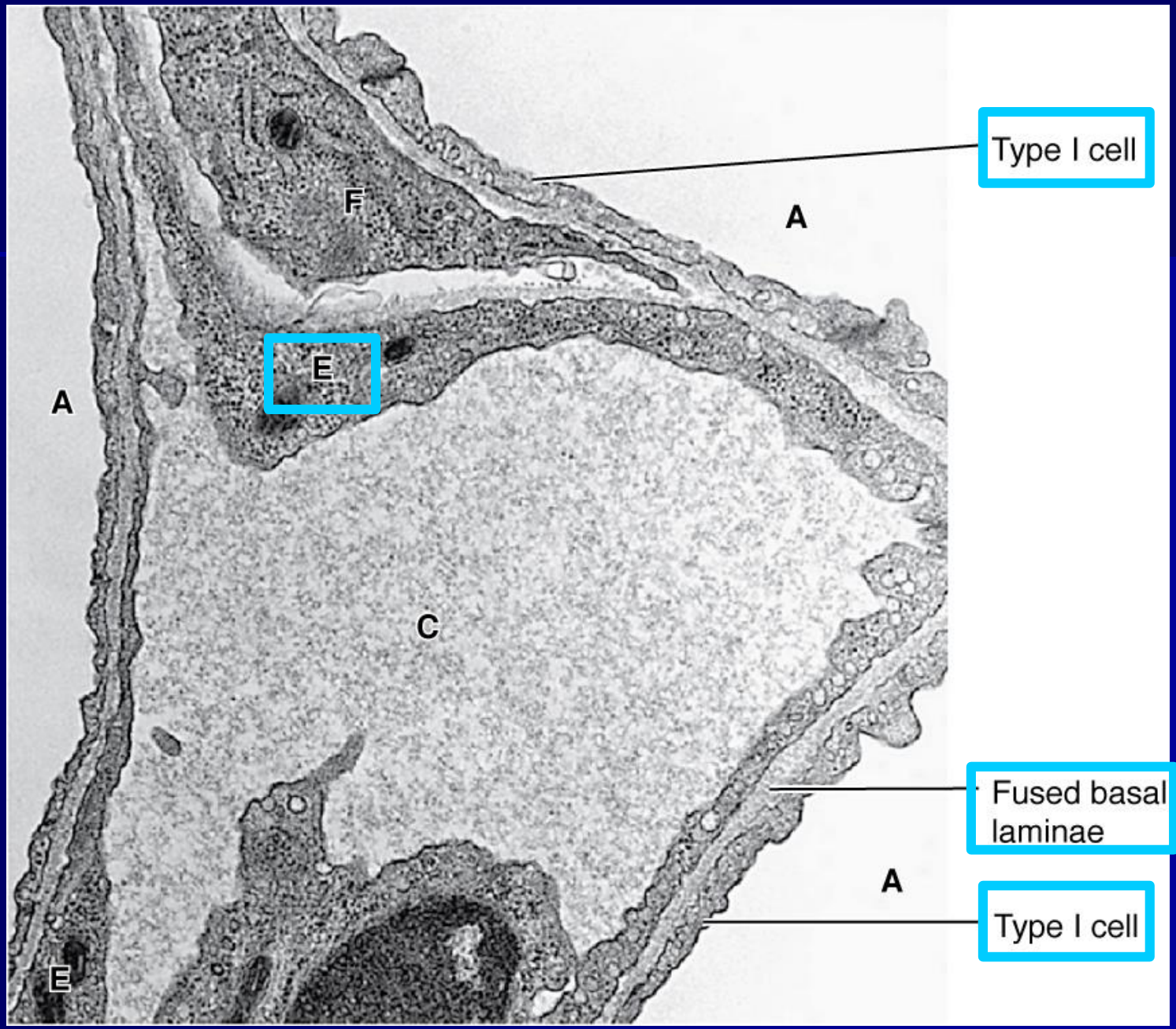


The blood-air barrier



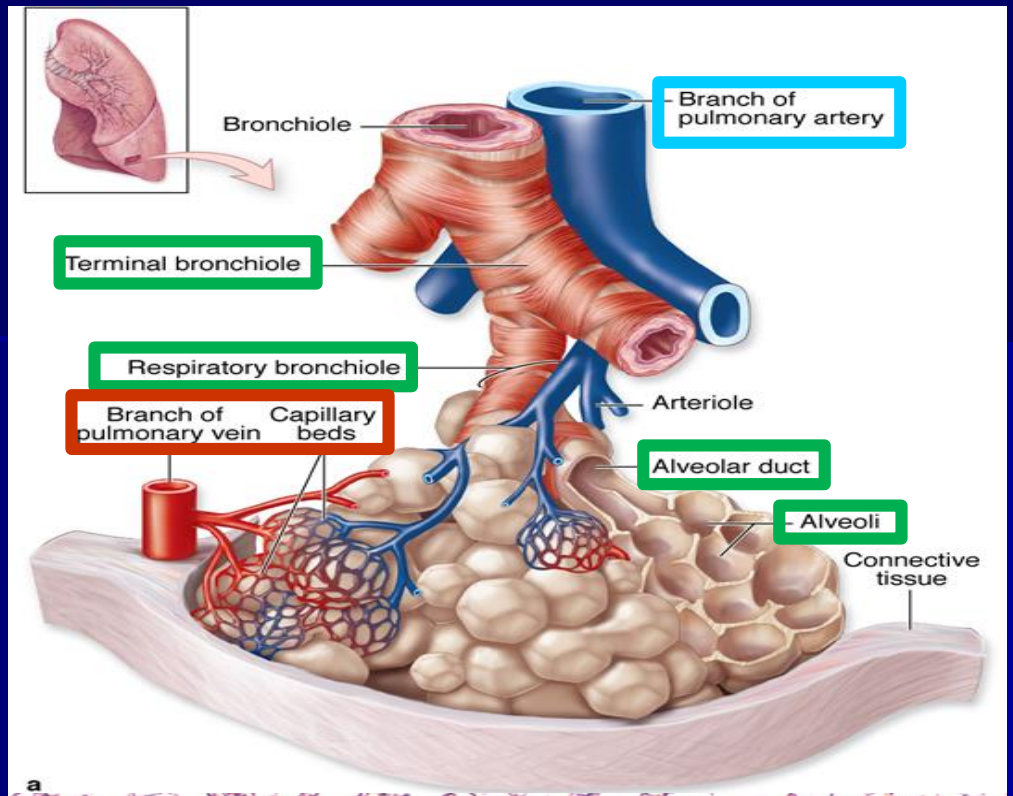


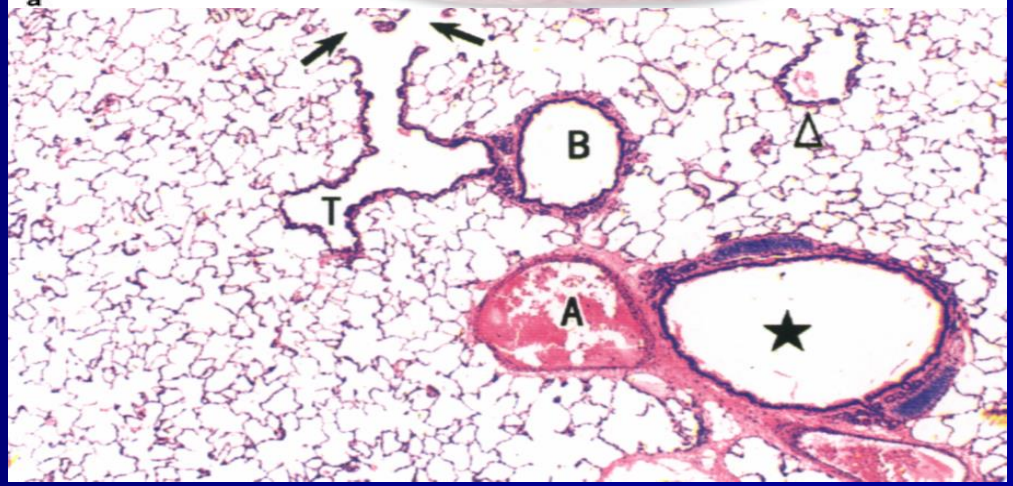
The blood-air barrier



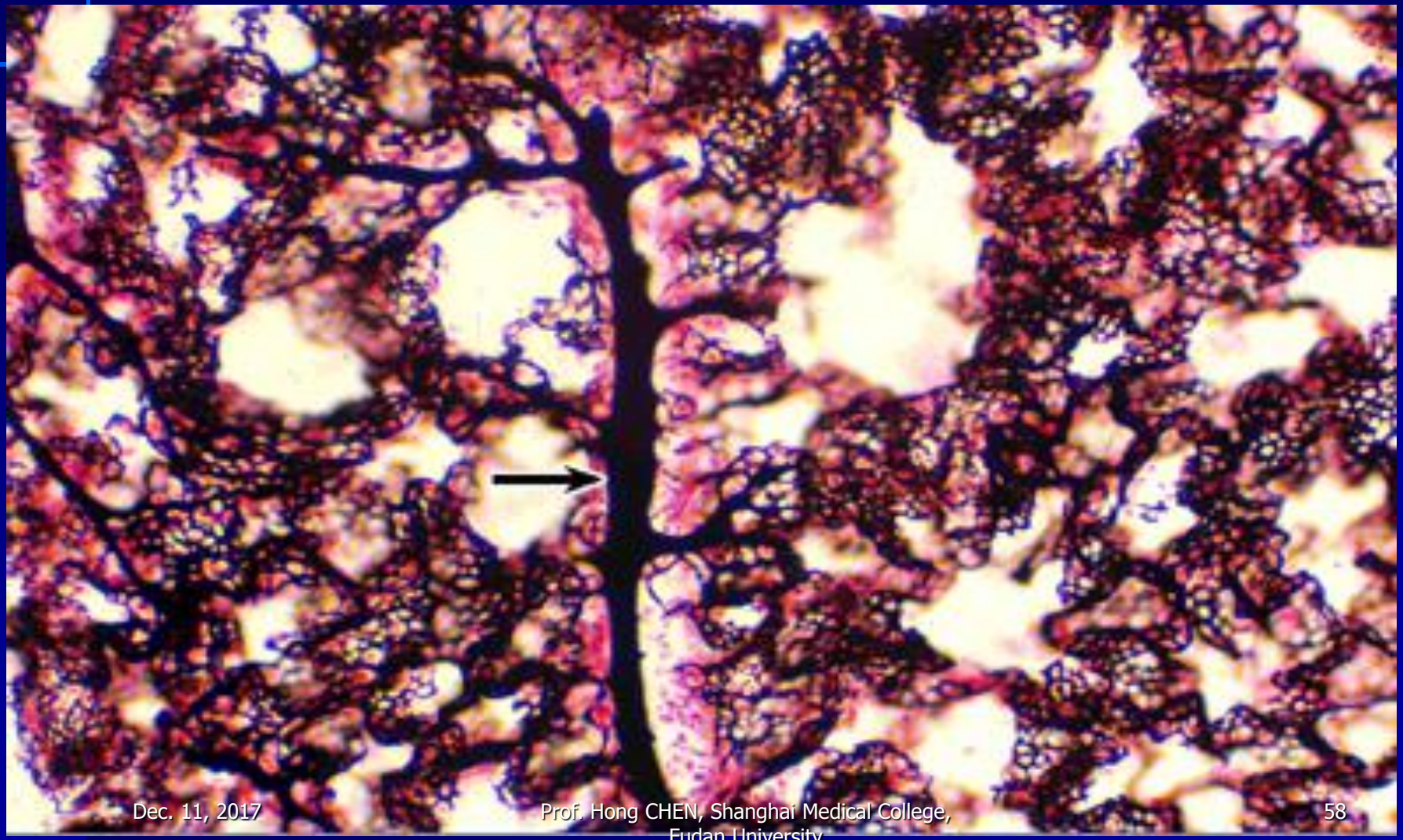
PULMONARY VASCULATURE

- **Functional**
  - **PA companying BT→ CA → PV**
- **Nutrient**
  - **BA →CA (conducting portion)→BV**

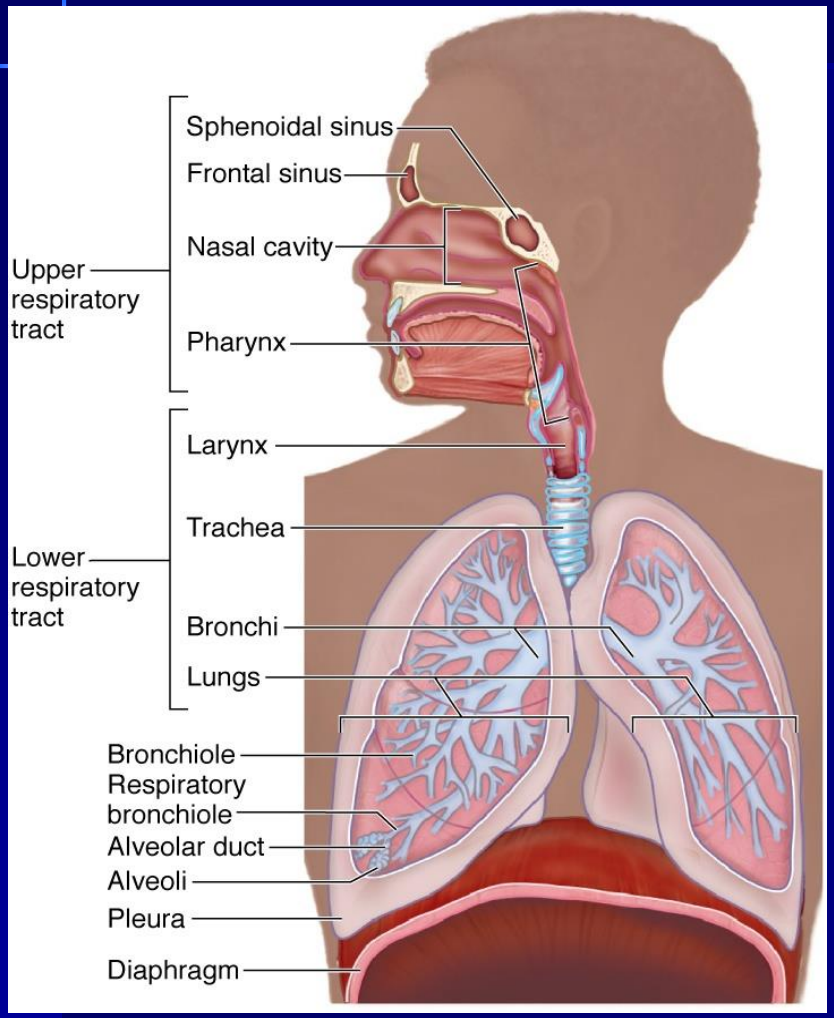




Pulmonary Vasculature
(rabbit PA injection with Chinese ink)



Particulate Matter and Its Fate in the Respiratory System



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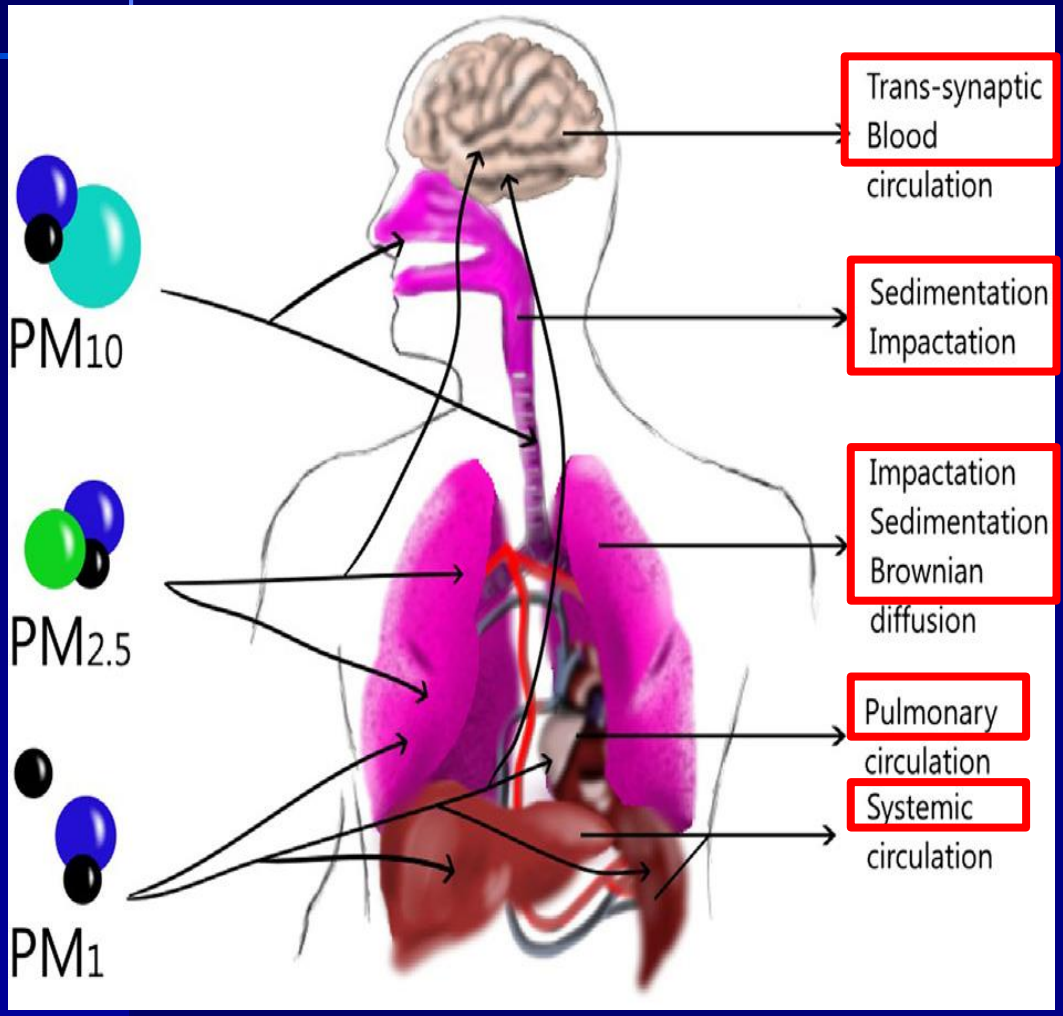
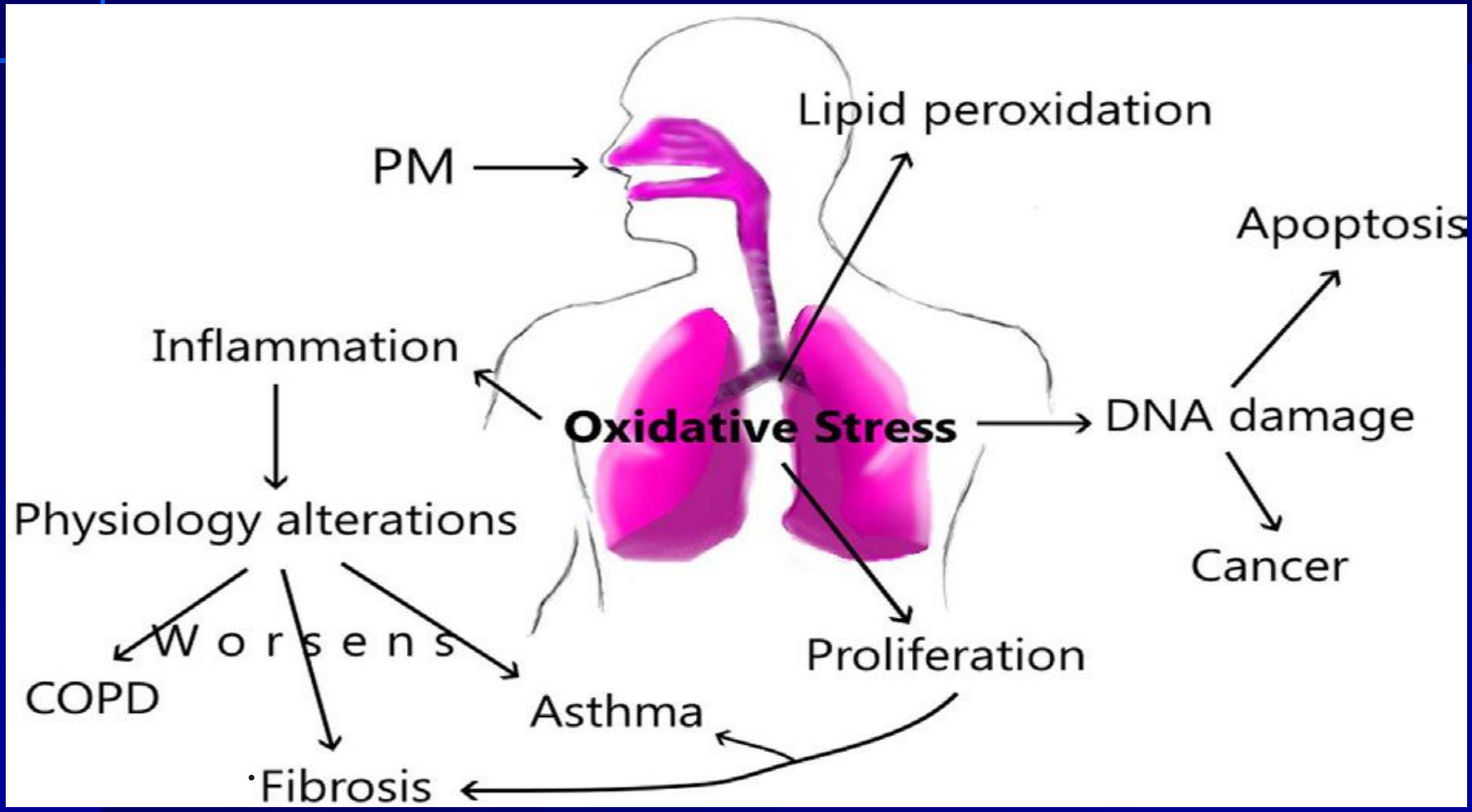
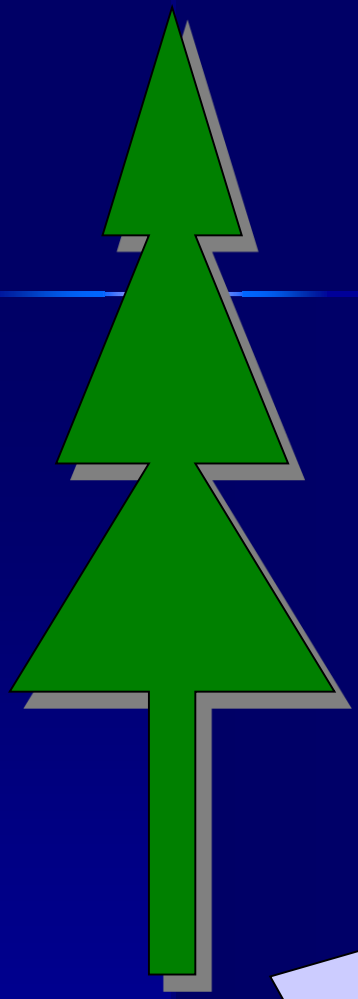
Size and Dynamic of particles in the lung and other tissues



- **Large particles** can be deposited in **upper airways** through **sedimentation or impaction**
- While in the lower airways **Brownian diffusion** can deposit **fine particles** in **the alveoli**.
- **Ultrafine particles** can translocate to **blood-circulating** and be deposited in the **liver, spleen or brain**, although they might also penetrate through **trans-synaptic** mechanisms.

The Principal Route of Damage After PM Exposure





Thank You All!

Let's take care of the LUNG of the earth!

REVIEW QUESTIONS

- What is the difference between respiratory mucosa and olfactory mucosa?
- How do you distinguish the various segment of conducting portion and respiratory portion of lungs?
- Based on your observation, identify and describe the structure and function of alveolar epithelial cell.
- What constitutes the air-blood barrier?